ROADS and STREETS

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The A. R. B. A. and Safety First

The American Road Builders Association has just undertaken a big task, namely, the gathering and dissemination of information relative to accidents on public highways, with the object of effecting a decrease in such accidents. It goes without saying that the daily papers will gladly publish any helpful information and suggestions that may be offered by the A. R. B. A. Hence the task that lies before the association is primarily one of gathering data about accidents, analyzing the data and drawing inferences therefrom. This is essentially an engineering problem of the first magnitude, and we are very glad that its solution has been undertaken by the A. R. B. A.

There is a close parallelism between many railway and highway problems, especially now that our highways are used mainly for fast moving motor vehicles. Yet there are so many differences between rail and road that the methods found effective in the one must usually be modified considerably before they are suitable for the other. Railway signalling, for example, is designed for use by skilled locomotive drivers operating, for the most part, on prearranged schedules. Highway signalling must be of a sort that even unskilled motorists can understand.

Practically all highways are at least of "double-track" capacity, whereas most railways are only single-track. Highways are usually intersected by other highways at frequent intervals, whereas railways intersect railways at infrequent intervals. Trains give warning by their noise, whereas motor vehicles do not.

It has been learned by some street railway managers that there is a vast difference between motormen as to the frequency of accidents. A large percentage of the accidents have been traced to a small percentage of the motormen, resulting in the transfer of careless motormen to other duties. Similar control over motorists may never be possible, yet it is not unlikely that records will eventually be kept of the number of accidents attributable to each motorist, and that some means will be found whereby the more careless and reckless drivers will be restrained.

Studies of accidents will doubtless disclose that poorly paved highways not only cause many accidents directly, but indirectly cause many more by increasing the congestion on well paved highways. Last year the city of Philadelphia paid $415,000 in liability awards for personal injuries attributable to poor pavements, according to the Keystone Automobile Club. This sum would pay the interest on $8,300,000 of street bonds at 5 per cent. The president of the Keystone Club asserts that fully 700 miles of pavement in Philadelphia need immediate reconstruction; but that Philadelphia is rebuilding only 37 miles a year. Facts like these will doubtless be gathered from many cities by the A. R. B. A. and their significance brought to public attention frequently by the daily papers.

The A. R. B. A. is to be heartily congratulated on having decided to sponsor a great "safety first" program for roads and streets traffic.

"State Roads Not Designed for Heavy Freight"

Governor Fisher of Pennsylvania said in a recent message: "State roads were not designed as trunk lines for heavy freight. There must be no monopoly of the people's highways and neither shall they be destroyed by improper use."

Few will dissent from this statement provided that it does not imply a decision to exclude very heavy wheel loads forever from state highways. But we fear that the governor of Pennsylvania had in mind no plan of building highways that could be used for heavy freight, else he would have mentioned the plan.

When the wheel load on a bridge threatens its destruction, of course such a load should be prohibited. And the same holds true of a pavement. But that is quite a different matter from refusing to rebuild a bridge or a pavement so that it will safely support greater wheel loads.

Hauling by motor trucks is still in its early stages of evolution; but it has already developed so rapidly as to make it necessary to increase the thickness of pavements. Who can tell where this evolution will lead, or how rapidly our present standards of pavement design should be changed?

Study the history of the changes in standard rail sections for American railway traffic if you want a rough parallel to the probable history of pavement standards. A steel rail will last a century, so far as wear is concerned, but the actual life on the average American railway has been about 20 years. This also has been about the average life of the "permanent" steel bridges. The reason is that the average life of the locomotives has been only 20 years or so, lighter locomotives giving place to heavier at such a rate as to result in an average economic life of about one-fifth of a century. Had American railway presidents refused to rebuild their roadbeds to accommodate the growing weight of their rolling stock, this country would not now enjoy the distinction of having the lowest ton-mile rail costs in the world.

Unfortunately for highway development, there is no such unity of purpose in building and operating highways as is the case with railways. In fact there is often a direct conflict between the builders of highways and many of the users of highways. Quite naturally the highway engineer is often not in sympathy with the truck owner who wishes to use greater wheel loads. But such antagonisms should not be permitted to stop the economic progress of motor trucking.

Economic progress is never had without cost. Functional depreciation has been properly called the cost of progress. If the profit of progress exceeds the cost, the cost is justified. In the electrical field functional depreciation of plant has frequently exceeded 10 per cent annually; but the reduced cost of production has usually justified the scrapping of "perfectly good equipment"—"good," in the sense of physical soundness. Therefore, in considering the destruction of pavements that were intended to be permanent, let us not be too apprehensive. Permanence is no proof of excellence. Indeed, it is often an evidence of exactly the opposite. There is scarcely anything more permanent than a dirt road, unless it be the old stone wheelbarrow roads of China. No noticeable change there, century after century. Also no progress.

H. P. Gillette

Politics in Road Building

Editorial in New York Herald-Tribune

A piece of political jobbery has just been perpetrated in New Jersey, in the changing of the personnel of the State Highway Commission. That body consists of four members, two of them being from each of the two parties. For four years it has been doing admirable work, as all are agreed, without suspicion of political partiality or patronage. The best interests of the state would be served by its continuation in its present form.

The state, moreover, is on the point of beginning a system of road building which will involve the expenditure of from $160,000,000 to $200,000,000 in the next half dozen years; wherefore there are the strongest of additional reasons for keeping politics out of the commission and keeping in it men of experience and technical knowledge.

Yet Governor Moore has just declined to reappoint a member who is a practical engineer and who is generally recognized as of exceptional value to the commission and to the state, and has appointed in his place an estimable druggist, who has no experience or special knowledge of road building, but who is regarded as an adroit and efficient "practical politician."

Both the retiring commissioner and the new appointee are Republicans, so that the governor has not broken the bi-partisan rule. But he has for the first time injected politics into the commission. It is understood that he made the new appointment at the request of certain Republican leaders who were afraid that Frank Hague would have the Democratic members gobble up all the patronage for that party if they did not have a more active and aggressive Republican on the commission to grab a goodly share of it for his deserving friends.

Thus notice is practically served upon the state that its big appropriation of $160,000,000 or more is to be administered primarily for the benefit of the politicians and only secondarily in the interest of the people.

Relief of Traffic Congestion by Signal Lights

Editorial in New York Times

One measure for the relief of traffic congestion in the streets of New York has been a proved success. Control by lights may not be a fundamental cure for the disease, but at least it manages to keep the fever down. The system has been improved steadily year by year. Tried out at first on a single avenue, it has now reached a point of development where the main arteries of traffic are lighted and co-ordinated. Drivers and pedestrians are thoroughly accustomed to the new regime and realize its benefits. The system makes for the orderly and expeditious handling of traffic and has plainly come to stay.

Commissioner McLaughlin wants it still more widely extended. There is every reason that it should be. The city may be too cramped for funds just now to authorize the whole expenditure at once, but it should provide for steady expansion. Really, this is a matter of economy. When traffic towers were first set up on Fifth Ave., each one had to be manned by a policeman. Now all the towers on the avenue are under one-man control. In fact, towers are no longer necessary, and elsewhere they are being supplanted by lights attached to poles at the curb lines. In a booth under the Queensboro bridge there is a policeman who regulates all the lights on First Ave. from Twenty-third to 125th St., a distance of five miles. This shows the saving that can be affected by the age of electric "traffic cops."

Meeting of Association of Highway Officials of North Atlantic States

The Third Annual Convention of this Association will be held at the Hotel Ambassador, Atlantic City, N. J., Feb. 16th, 17th and 18th, 1927. The program committee has arranged a series of very interesting papers and discussions, and there will also be a highway industries exhibit. All indications point to very interesting sessions and a large attendance, including officials of the highway departments of the several states in the North Atlantic section as well as county, township and municipal officials, and others interested in the highway industries.

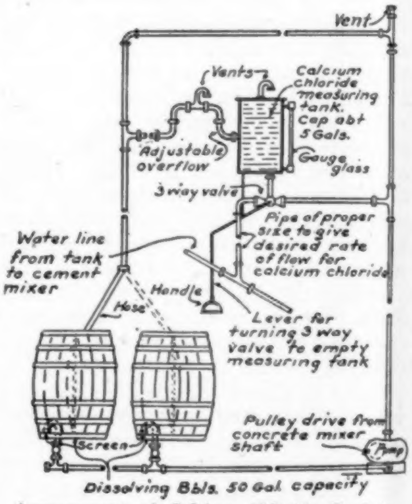
Gasoline Tax in Mexico.—The gasoline tax of 5.7 cts. per gallon in Mexico provides a fund of approximately $6,000,000 per year for road construction.

Use of Calcium Chloride as Curing Agent

Methods Used in Maine for Incorporating It in Concrete Mix

By L. D. BARROWS
Assistant Engineer, Maine Highway Commission

The increasing interest and success in the use of calcium chloride as a curing agent for concrete led the Maine Highway Commission to study the method for proper incorporation of the calcium chloride solution with the concrete mix. In order to insure proper curing by incorporating calcium chloride a definite amount of the calcium solution must be added to each batch of concrete. This is done in some cases by simply dumping the proper amount of solution with a pail into the drum of the mixer. The assurance that the accurate amount is added and at the



Arrangement of Calcium Chloride Feed to Concrete Mixer

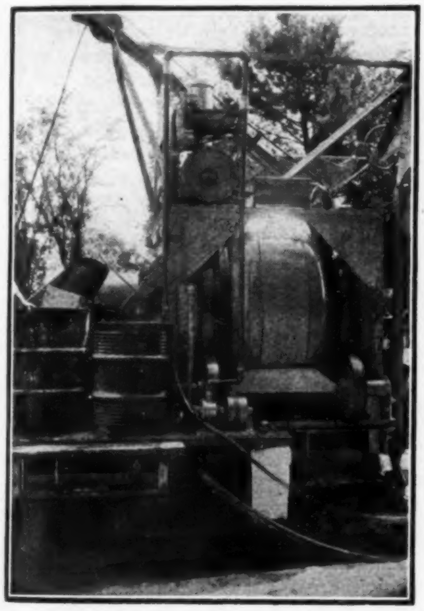
proper time is placed entirely upon the operator. To eliminate this personal element, a machine has been devised which automatically pumps and measures the solution, discharging the measured amount at the proper time after the concrete materials have been dumped into the mixer drum.

The equipment consists of a mixing and pumping unit and a measuring unit. Two barrels compose the mixing unit, one of which is used to mix the solution while a similar solution is being pumped from the other into the measuring tank from which it is discharged into the water line leading into the mixer drum. A 50 gal. barrel should be filled about three-quarters full of water to which should be added 200 lb. (2 bags) of calcium chloride and stirred until all the calcium chloride is dissolved. Enough additional water should then be added to fill the 50 gal. barrel and the liquid stirred to make the solution uniform. The pump runs con-

tinuously from a moving shaft of the mixer, the liquid overflowing from the measuring tank into the barrel from which the solution is being pumped.

A 3-way discharge valve is controlled by the skip lever so that the solution is added in proportion to the amount of cement, and at the same time as the water is being discharged into the drum. When the valve is opened for discharge from the measuring tank the intake is closed and the liquid is passed through the by-pass so as to allow the continuous pumping operation. A glass gauge is placed on the measuring tank so that easy observation may be made of the operation.

Empty oil barrels may be used for the mixing tanks, cutting out the plain end and installing the pipe in the fittings found in the other end of the barrel. A small gear pump is satisfactory for lifting the solution to the measuring tank and may be run from any moving shaft of the mixer or by a belt encircling the drum.



Calcium Chloride Equipment on Concrete Mixer

Care must be taken to keep the solution clean and free from small hard grains, as sand, or difficulty may be encountered with the pump. To guard against this a short piece of pipe should be run up inside the barrel with a U nipple having the end covered with a screen.* Standard 1¼ in. pipe is satisfactory for intake into the measuring tank. The outlet should be of a size that the required quantity of calcium chloride solution will empty in the same time as the tank of mixing water.

The attached drawing shows how this apparatus may be used with any type of mixer and the photograph shows the apparatus as placed, under the supervision of The Solvay Process Co., on a new Multi-Foote mixer, by the McCormick Construction Co. at South Paris, Me.

With this apparatus the calcium chloride solution is definitely discharged into the mixer drum at the same time with the water without the mixer operator being required to give any special atention.

Proper inspection is easily carried on. The strength of the solution may be checked by the use of a hydrometer. The measuring tank may be calibrated. It may be easily determined by observing through the glass gauge that the solution rises in the measuring tank in short enough time to insure the full quantity of calcium chloride for each batch.

This method not only insures the proper incorporation of the calcium chloride solution, and therefore uniform curing of the concrete, but is labor saving as it requires but one man to carry on the curing. No covering or other curing is needed except during the summer months, when wetted burlap should be placed immediately on the concrete.

*Covers should be provided for these barrels to assist in keeping the solution clean.

Cost of Highway Engineering and Administration in Iowa

According to the Service Bulletin of the Iowa Highway Commission the cost of engineering and administration during the year 1926 on the Iowa primary and secondary road projects handled by the commission was 5.79 per cent of the total expenditures for these purposes. Since the first law was enacted in 1917 accepting federal aid $92,895,276 has been expended on the primary road system under the commission supervision. This expenditure is classified as follows:

Construction	$70,234,503
Maintenance	17,202,654
Engineering and Administration	5,458,118
Total	$92,895,276

Expenditures for engineering and administration amount to 5.88 per cent of the total expenditure. This expenditure includes every item of engineering and overhead, the expense of every nature incurred by the commission in connection with the work on primary roads. In addition to this primary road expenditure there has been expended $1,344,644.17 from the primary road fund for construction work on the secondary roads. It takes as much work in the highway commission office to administer a project on a secondary road, payable out of primary funds, as it does for a project on the primary system. Highway Commission engineers give general supervision to construction work on all primary-secondary projects. Taking this expenditure on primary-secondary projects into consideration the cost of engineering and administration on all expenditures from the primary road fund is 5.79 per cent of total expenditures.

Contract Control

Experiences in North Carolina Outlined in Paper Before American Road Builders Association

By LESLIE R. AMES
State Highway Engineer of North Carolina

The annual expenditures for highways in the United States at the present time will exceed one billion dollars, of which approximately 60 per cent is expended for construction. It would seem therefore a conservative estimate to say that contracts on highway work to the extent of $500,000,000 are awarded annually. This large sum divided, as it is, into thousands of contracts, makes the question of "Contract Control and Engineering Service" a very vital one.

The State of North Carolina has expended approximately $125,000,000 in the past five years on construction work, and during that period we have learned some lessons on "Contract Control," and I am taking the liberty of setting forth a few of our experiences.

Start Before the Award.—We have found that the most important time to start "Contract Control" is before the award of the contract. Contractors, bonding companies and state highway departments would save thousands of dollars annually if contracts were awarded only to the lowest responsible bidders. Too often an irresponsible bidder can secure a bid bond from a local bonding agent, who only considers the benefit he derives from his portion of the premium and this places the state highway official in the embarrassing position of being charged with favoritism or graft, if the irresponsible bid is rejected and the contract awarded to the lowest responsible bidder.

Before awarding a contract, we require a financial statement and an experience questionnaire to be filled out. These statements are carefully investigated and never intentionally is a contract awarded to an irresponsible bidder.

Change in Contract Form.—Formerly our contracts specified that working days would start 10 days after the execution of the contract. In many cases, the contractor purposely delayed the execution of the contract, not being prepared to start construction, thus leaving the state highway commission without redress. Consequently our contracts were changed to read that "Working days shall start 20 days after the date the contract is mailed for execution," and this change has settled many arguments regarding the beginning of the working time of a contract. We allow contractors to bid on the number of working days to complete the project, and in the compilation of bids, these working days are figured on a basis of $20 per day which approximates the cost of engineering. If

the contractor overruns his working time agreed upon in the contract or within such extra time as may have been allowed for delays by formal extensions, a deduction of an amount equal to the actual cost incurred by the state highway commission is made for each day that such contract remains uncompleted. This amount is considered as liquidating damages on account of the expense due to the employment of engineers, inspectors and other employees after the expiration of the number of working days agreed upon and is deducted from the final estimate.

Interpretation of Specifications.—The successful administration of any construction contract is dependent to a large degree upon the character of the specifications and their proper interpretation. Specifications should be so worded as to clearly state the necessary requirements, and all indefinite clauses should be eliminated so far as possible. If specifications are in any way uncertain, allowing the engineers and contractors wide freedom in their interpretation, there is always a feeling of suspicion on the part of the contractor that he is not getting a square deal. For that reason, our specifications should be specific, instructive and in detail, and thus enable the contractor to know clearly the character of work.

Testing of Materials.—Previous to the large construction program, our state depended upon commercial companies for its testing of materials. However, when work increased in such tremendous proportions, it was found to be more economical and more satisfactory to establish both a physical and chemical laboratory. These laboratories have been equipped with modern apparatus and serve as a means of rendering valuable service to the contractor as well as an indispensable guide in directing the work. All stone, sand, water and other materials are tested at the physical laboratory and daily samples of pavement on asphalt projects are sent in to the chemical laboratory to be checked for gradation, quality and density.

Inspection and Reports.—One of the most important elements connected with any large construction program is competent and intelligent inspection. It has been our experience that this can best be handled and supervised by central office control, and operating out of the central office are construction engineers making periodical visits to each project. These men correlate and standardize all work under way in such a manner that the same type of construction and methods may prevail throughout the state. This type of service is especially important on account of the fact that whenever any state inaugurates a large road building program, contractors are attracted from all parts of the country which results in many conflicting ideas regarding the methods of workmanship.

In order that the central and district offices may keep in close touch with the work under way daily report cards are sent to both offices by the resident engineers and detailed records are made up from these report cards. If at any time any irregularity occurs, or the details appear questionable, the project engineer is immediately notified to correct the difficulty at once. By this method the contractors' as well as the state's are protected. We also have monthly progress reports made up showing working days as the coordinate and the total quantities as the abscissa. Only the major items of the contract are shown on this report, which is made from the quantities as taken from the monthly estimates. As soon as it is noticed that a contractor is falling behind in his progress the matter is brought forcibly to his attention and he is requested to report on his future plans for speeding up the work. We have found that this system works very satisfactorily and in the majority of cases brings results. If the work is further delayed, a conference is called between the contractor, the bonding company's agent and representatives of the state highway commission.

Bonding Companies May Help.—Provided the contractor is able and willing to proceed, the bonding company can often succeed in ably assisting the contractor, financially or otherwise, and save an actual default. I have in mind a report from one of our construction engineers which was made after visiting a grading project which read in part as follows: No mules, no wagons, no scrapers, no money, no progress, no nothing.

Strange as it may seem, we struggled along, foolishly perhaps, with this contractor, and he finally completed the work. He was satisfied, however, at the completion of the work that his services would no longer be required.

Finally, we have the contractor who goes from bad to worse, and it becomes necessary to default the contract. The inside workings of the bonding company are then brought to light. We have had one bonding company in particular with whom it has been a genuine pleasure to work. This particular bonding company has a "trouble man" who is sent direct to the work as soon as notified that a contract is to be defaulted. This man is an engineer with a wide experience along this line of endeavor, and within a few days after the actual default he will have work resumed in a satisfactory way, saving time and money, not only to the state, but also to the bonding company. We regret, however, that our experience with some bonding companies has not been so pleasant and it often takes a long drawn out and painful operation between the time of the default and the resumption of work.

Engineering Service. — During all these various phases of "Contract Control," "Engineering Service" plays an important part. Without satisfactory engineering service you cannot have satisfactory contract control, and the reverse of this statement is also true.

One very important service that the engineer should render, and one that is too often overlooked, is in laying out the work well in advance of the contractor's operations. No matter how capable the contractor or how favorable the conditions, an engineer can delay operations by not having the work laid out well in advance. At times the contractor is responsible for this delay in not giving the engineer sufficient advance notice of his plans. Another cause is often due to the contractor's inability to make uniform progress, thus making efficient engineering service difficult, if not impossible.

An engineer is educated and trained to be accurate. But even then mistakes are made, and these errors are costly to the contractor in both time and money. Instead of waiting for the contractor to discover these errors, the engineer should check his work promptly in order to prevent delays and the suspension of work, which is costly to the contractor.

The majority of states are divided into construction districts or divisions, and it is very essential that work should be uniform and the requirements the same in each district or division. In practice, this objective is very difficult to obtain. However, a contractor cannot bid on a project intelligently unless he knows in advance the requirements, and it should not be necessary for him to bid higher in one district than another on account of uncertainties of these requirements. This fact, I believe, is a very strong argument for central office control.

Cooperation With Contractors.—The question of "Cooperation With Contractors" alone is of such importance that there is a special committee of the American Association of State Highway Officials appointed to work on this problem. A contractor should be made to feel that it is his right and privilege to appeal from a decision made by any subordinate to the highest official in the state highway commission, provided he feels that he is being required to do work not included in the specifications. It is my opinion that not only the quality of the work done, but also the unit bid prices are materially affected by the degree of this cooperation between the engineer, the state highway official and the contractor.

Well regulated contract control can be the means of elevating the standard of performance in the contracting industry, thus enabling honest and competent companies to survive. Then the engineering service as now rendered by most states in cooperation with these companies will result in a better standard and quality of work and in the end give the ultimate pavement that all engineers and contractors are striving to obtain.

The Ultimate Highway Development

The Widening of Trunk Lines vs. Building Parallel Highways Discussed in Paper Presented Jan. 11 at 24th Annual Convention of American Road Builders' Association

By BEN H. PETTY
Assistant Professor of Highway Engineering, Purdue University

With motor vehicle registration in this country increasing at the rate of approximately 13 per cent per year and the so-called saturation point still invisible, the question of either widening existing pavements or building parallel routes has become a major problem in thickly populated areas and will confront the highway officials of every state in the very near future. California now has approximately one motor vehicle to every three persons within its borders. Isn't it quite possible that within a few years the entire country may approach this degree of saturation? This would mean a total of some forty millions of vehicles, twice the present registration.

The problem covered by the subject of this paper is one that has developed largely during the past five years. In that period the registration of motor vehicles in this country has increased 100 per cent, or in round numbers, from 10,500,000 to 21,000,000. Increased registration naturally means increased traffic. The following table, showing results of traffic counts at eighteen observation stations in Massachusetts during successive three-year period from 1909 to 1924, illustrates the great increase in traffic during the past few years:

Cahuenga Pass Road, Los Angeles County, California. Pavement 72 Ft. Wide

Year	Average Vehicles Per Day	Per Cent Increase over 1909	Per Cent Increase Per 3 Yr. Period
1909	270	.....	.....
1912	430	59	59
1915	760	181	77
1918	1180	337	55
1921	1950	622	65
1924	3721	1279	91

Similar results are shown by annual traffic counts on the Maryland state highways from 1917 to 1924 as indicated in the following table:

Year	Per Cent of Yearly Traffic Increase
1918	7.4
1919	28.2
1920	23.7
1921	22.3
1922	7.8
1923	25.4
1924	12.7

Highways Badly Congested.—As a result of this great increase in motor traffic, highways which only a few years ago were entirely adequate, are today so badly congested that in some cases they are actually handling less than full capacity of traffic.

It is rather amusing now to recall some of the many criticisms hurled at those officials responsible for the ideal section of the Lincoln Highway constructed near Dyer, Ind., about 20 miles south of Chicago, in 1922. The idea of a 40-ft. paved roadway in a rural district was considered preposterous by some and prophesies were made that traffic would never demand such a width of pavement. But already we have gone far beyond this limit in some communities with widths of 50, 60 and even 72 ft. of pavement on suburban roads.

A subject of this kind is more or less of a controversial nature and definite facts and figures supporting either side of the question are somewhat scarce. It has been the writer's plan in developing this paper to present some of the more noteworthy examples of both pavement widening projects and developments of parallel routes and then follow with some of the more convincing arguments both for and against each of the two plans for relieving traffic congestion.

Examples of Widening.—Some of the more notable examples of pavement widening in various parts of the United States are as follows:

1. That part of the Boston Post Road running north from New York City across the state of Connecticut to New Haven is one of the heaviest traveled roads in the East. In an effort to relieve the serious traffic congestion, the Connecticut highway officials have started a program of progressive widening on that part of the road extending from the New York state line to New Haven. The pavement is being widened to 36 ft., providing four 9-ft. traffic lanes.

2. The historic White Horse Pike extending 50 miles from Camden, N. J., to Atlantic City is being widened to accommodate the tremendous volume of motor traffic that pours into the famous seaside resort. The pavement is being widened by the addition of concrete shoulders. When the program is completed a paved width of 30 ft. will be available throughout its entire length. More than half of this widening was completed during 1926.

The traffic on this road has been greatly increased since the opening of the Philadelphia-Camden suspension bridge over the Delaware River. The highway forming the Camden approach to this bridge is being widened to a paved width of 76 ft. between curbs. W. S. Dean, state highway engineer of New Jersey, predicts that this section of paved highway will handle over twenty million vehicles per year. This practically equals the total registration of motor vehicles in the United States at the present time.

3. During the last two years, the Lincoln Highway west of Philadelphia has been widened from 20 ft. to 40 ft. by building 10-ft. concrete slabs either side of the old 20-ft. bituminous macadam pavement. This is termed a "dual type" pavement. Progressing further west from Philadelphia this total width is reduced to 30 ft. and finally merges into the standard 18-ft. pavement.

4. Michigan provides several examples of wide pavements. One of the most notable being the Detroit-Pontiac

Albany Post Road, Westchester County, New York. Paved 24 Ft. Wide in 1924; Widened in 1925 to 36 Ft.

superhighway, known officially as Wider Woodward Avenue. This consists of a 204-ft. right of way carrying two 44-ft. concrete slabs separated by a 40-ft. car track section, thereby providing a complete separation of traffic in opposite directions. Kent County has fixed 40 ft. as a minimum pavement width for future construction.

5. The Portland-Kittery highway, which is estimated as carrying 75 per cent of the tourist traffic into Maine, is being widened to 27 ft. by the construction of 9-ft. concrete slabs each side of the present 9-ft. bituminous pavement.

6. In 1925 the Cahuenga Pass Highway leading out of Los Angeles to the north was paved to a width of 36 ft. Within a few months this width proved inadequate to handle the rapidly increasing traffic and during 1926 it was widened to a total paved width of 72 ft. This is one of the widest suburban, continuous pavements to be found in this country.

7. The biggest single program of wider highways ever undertaken is now under way in Cook County, Illinois. The program will bring about the pavement widening to 40 ft. of 125 miles of main highways and the building of 247 miles of new 20 ft. pavements, in addition to widening shoulders, intersections and connecting city streets. A total of over 500 miles of streets and roads is affected at a cost of $32,000,000.

Du Page County, adjoining Cook County on the west, is planning three so-called super-highways extending east and west across the county. The plans call for 200-ft. rights of way with two 40-ft. pavements separated by a parkway and car track section 45 ft. wide. All other state and county roads will have rights of way of 100 ft. and 66 ft. will be the minimum for roads of lesser importance.

Arguments Favoring Wide Pavements.—The arguments advanced in favor of widening our standard, two-lane, paved highways may be summed up as follows:

1. Providing more than two lanes for traffic reduces possible accidents due to attempts at passing around slow moving vehicles.

2. Three or more traffic lanes greatly increase the carrying capacity of a highway since the extra lanes permit fast traffic to pass around trucks and other slow moving vehicles, thereby raising the average speed of all vehicles using the road.

Arguments Against Widening.—The following arguments may be advanced against the policy of widening our standard two-lane pavements.

1. It increases danger due to high speed on the adjacent inner lanes, the slow traffic being relegated to the outside.

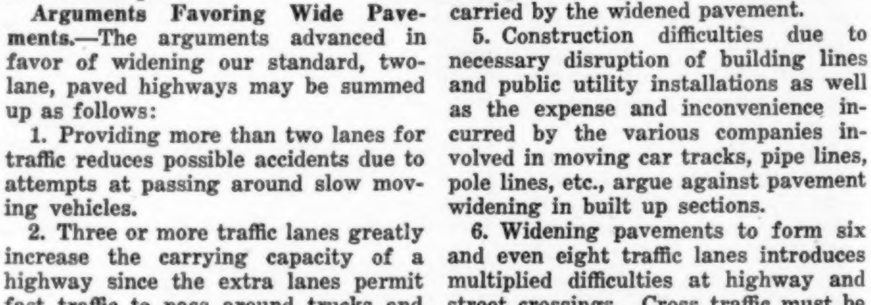
2. Great expense is involved in securing the needed right of way for widening, after adjacent property values have been greatly boosted by the construction of the original pavement. Almost invariably the paving of a highway brings about an increase of property values alongside. On roads leading out of our cities this increase may be manyfold in a reasonably short period of time. Buildings immediately spring up along such roads extending farther and farther from the city resulting in almost urban conditions for several miles beyond the city limits.

3. Traffic congestion will be intensified at points where such widened highways pour their traffic into the cities or into other rural traffic arteries.

4. Adjacent property owners object to the multiplied noise and confusion incident to the greatly increased traffic carried by the widened pavement.

5. Construction difficulties due to necessary disruption of building lines and public utility installations as well as the expense and inconvenience incurred by the various companies involved in moving car tracks, pipe lines, pole lines, etc., argue against pavement widening in built up sections.

6. Widening pavements to form six and even eight traffic lanes introduces multiplied difficulties at highway and street crossings. Cross traffic must be justly cared for. If uniform interval



Boston Post Road, Westchester County, New York. Pavement 32 Ft. Wide

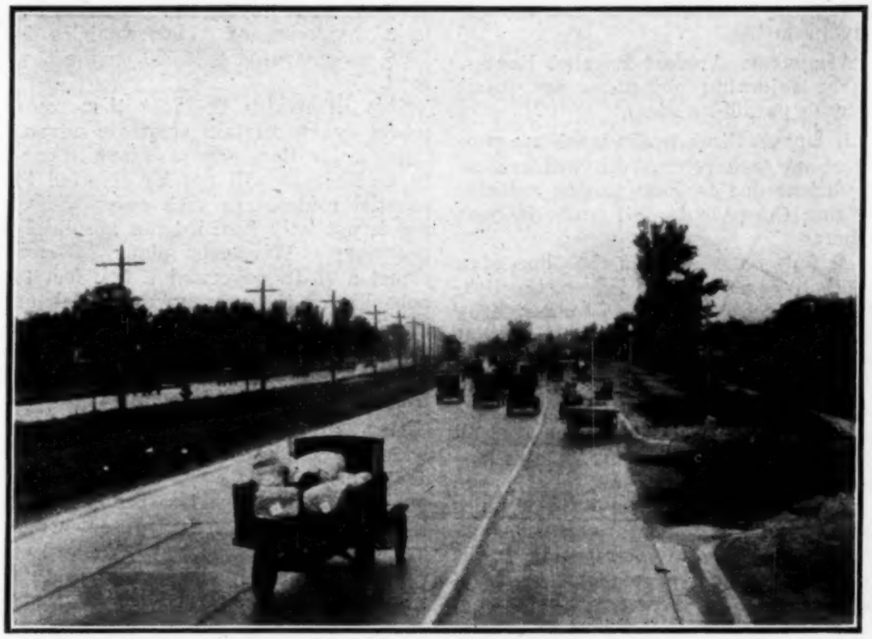
stop-and-go signals are installed, the heavier traffic on the wide road is frequently delayed and the capacity of the road is greatly decreased. On the other hand, if non-uniform time signals are installed it may work an injustice on the cross traffic.

The Pedestrian Problem.—In cities a serious problem is presented in getting pedestrians safely across the very wide streets. Some have suggested "islands of safety," spaced at regular intervals, across the street to aid pedestrians in a safe crossing. These islands bottleneck the boulevard and greatly reduce its efficiency.

The apparent solution to this crossing problem involves the construction of either underpasses or overhead crossings so as to permit the traffic to use the widened pavement to its fullest capacity. Of course, this would involve enormous expense and would be quite impractical on highways having cross roads at frequent intervals.

Examples of Parallel Roads.—To the writer's knowledge, there are very few examples of parallel highways constructed with the idea that they were to serve as parallel routes. It is true that there are some localities in which highways constructed some years ago are, as a result of enormous traffic increases, now functioning as parallel highways as we understand the meaning of the term. This is illustrated by the highways leading out to the west from Philadelphia. In addition to the Lincoln Highway there are three other state highways of major importance, lying to the south, which handle great volumes of traffic.

Similar conditions exist in the vicinity of Chicago. The new road program for Cook County provides for the construction of about 250 miles of new pavement that will, in reality, serve as a network of parallel routes for dispersing traffic. When completed there will be at least ten paved roads radiating out of Chicago to the northwest. These possibly could be classed as parallel roads insofar as the dispersion of outgoing traffic is concerned.



Woodward Ave., Oakland County, Michigan, One of the Superhighways from Detroit. Two 44-Ft. Pavements

In Westchester County, New York, a parallel route to the Boston Post Road is being constructed and surveys are being made for a parallel route to the Albany Post Road. In addition the county is spending considerable sums in the building of fast traffic routes or parkways on which business traffic is excluded and the light or pleasure traffic is allowed to travel at the rate of 35 miles per hour. Grade crossings are eliminated so that there is very little interruption in the flow of traffic. These parallel routes are being constructed 36 and 40 ft. wide.

In the vicinity of Cleveland and other centers of unusually heavy traffic in Ohio a program of parallel highways is being carried out. In some cases this results in a boulevard system consisting of two 18 to 30-ft. pavements with a parkway between.

Another Superhighway Leading from Detroit. Woodward Ave., Wayne County, Michigan. Two 44-Ft. Pavements

Arguments for Parallel Roads.—Those who favor parallel routes reason as follows:

1. Better dispersion of traffic is obtained which reduces congestion and probability of accidents.
2. The construction of parallel routes boosts real estate values along the new location, thereby increasing prosperity of the owners and providing greater resulting revenue from taxation.
3. As a rule, the right of way needed for a parallel route can be secured much more cheaply than the necessary right of way for widening an existing, over-loaded highway the original construction of which greatly increased property values alongside.
4. Paved road benefits and service are extended to more taxpaying units.
5. Makes possible the segregation of traffic by assigning truck and slow moving vehicles to one route and high speed traffic to the alternate route. By this plan the pavement carrying heavy truck traffic can be designed of adequate thickness to safely withstand the action of the traffic, while the parallel road carrying the lighter traffic, can be built thinner. Obviously this makes

possible a considerable saving of taxpayers' money.

Arguments Against Parallel Routes.—The following objections are pertinent to parallel routes:

1. Unless three traffic lanes are provided on each route, both will become inefficient due to slow moving vehicles setting the pace for all traffic in each lane.

A few years ago, at the time of a football game at New Haven, the Boston Post Road became so congested by a mixture of slow and fast vehicles that the average traffic velocity was from 10 to 18 miles per hour. In order to speed up traffic, one of the division engineers with his assistants removed all trucks and "mopes" from the two-lane pavement and as a result the average traffic speed increased to 30 to 40 miles per hour. This indicates quite convincingly the value of segregating traffic where two-lane pavements are concerned.

2. It is doubtful if two parallel, two-way traffic roads with 20-ft. pavements will carry as much traffic as one 40-ft. pavement. On the latter, slow speed traffic can be forced to the outer lanes, leaving the center for high speed. In cases of unequal volumes of traffic in opposite directions the four-lane road can still be used to capacity while the two-lane road is inefficient due to danger in passing around slow traffic.

3. In general, the number of drainage structures will be multiplied, thereby increasing the cost as compared with the extension of existing structures when pavements are widened.

4. The number of railroad grade crossings would be increased in many cases.

A Wisconsin Parallel Road.—A rather interesting situation has arisen in connection with a parallel road development in Wisconsin. State Road No. 19 paved to a width of 18 ft. from Milwaukee to Madison is one of the most important roads in the state. A peak traffic count on this road recorded 17,000 vehicles in 24 hours. It is estimated to carry an average daily traffic of 6,000 vehicles throughout the entire year.

About five years ago the state highway officials of Wisconsin conceived the idea of building a parallel road one and one-fourth miles south of Road 19 to relieve the serious congestion. This parallel road was so located as to lead directly from Waukesha, a city of 15,000 population, to Milwaukee, entering the latter on National Avenue, which is one of the principal streets on the south side. The high daily traffic count taken on Road 19, the year previous to the building of the parallel road was 11,500 vehicles. The first year the new road was opened it carried a maximum daily traffic of 5,500 as compared to 13,600 on No. 19. Traffic has increased more rapidly on the old road than on the new, culminating in a maximum of 17,000 vehicles in 1926, as compared to 8,500 on the new road.

This illustrates the fact that some roads, due to certain strategic advantages in location, must continue to carry traffic that will not be diverted to parallel routes. In such cases widening is not only justified but absolutely necessary. Wisconsin plans to construct a 40-ft. pavement a few feet to one side of the present 18-ft. slab on No. 19 and install one-way traffic regulations. Eventually this highway will consist of two 40-ft. pavements separated by a 30 or 40-ft. parkway.

Our great handicap now, where widening is desirable, is the lack of sufficient rights of way. Great sums of money could be saved to the taxpayer if those who planned our present street and road systems had only possessed the foresight to vision the present traffic and have provided sufficient rights of way to permit widening of pavements as necessary. It is rather presumptuous for us to blame our predecessors for this condition unless we clear ourselves of future censure by securing, at once, on our present roads, adequate rights of way to care for traffic increases for several years to come.

It has been proposed that highway officials adopt the policy of securing at once sufficient rights of way to care for the maximum practical future width of pavement. This would prevent the erection of buildings so close to the road that they would have to be moved later when pavement widening becomes a necessity. The excess land not used for present traffic could be leased back to the farmers for cultivation until needed for roadway purposes.

Providing Park Space.—In constructing wide pavements of four or more traffic lanes, it is desirable from the standpoint of safety to provide a park space at the center to entirely separate traffic moving in opposite directions. On wide pavements, slow traffic will naturally be crowded to the outer lanes, thus throwing the high speed traffic in close proximity at the central lanes. Considering the many careless, incompetent drivers on the roads today in addition to the dangerous "hip flask" drivers, it is quite evident that the park space separator is justifiable.

There is one handicap due to this park space that should be pointed out. Traffic flow in opposite directions is seldom equal. For example the traffic is usually greater toward cities in the morning and away from cities in the evening. The park space in a case of this kind would cause one-half of the pavement to be overcrowded, while the other half might be quite free of traffic. Where no park space is present, the denser traffic can spread out onto the unused lane or lanes of the other half of the pavement. While this may increase traffic hazards, it nevertheless utilizes the full width of the pavement.

Between Seattle and Tacoma plans have been prepared for a wide highway consisting of two 20-ft. slabs of concrete separated by a 4-ft. gravel strip. This will tend to separate opposing traffic, but by providing a graveled crossover it will still permit full utilization of the entire pavement during periods of unequal traffic flow.

Carrying Capacity of Pavements.—Due to the many variables involved and assumptions to be made, it is rather difficult to compute the theoretical maximum hourly vehicle capacity of highways. The total number of vehicles passing a given point in a unit of time in a single line is dependent on the velocity, spacing distance between vehicles and length of vehicles. A. N. Johnston, dean of engineering at Maryland University, has proposed the following formulas for use in determining the maximum traffic capacity of a road based on a single line of traffic:

(1) $N = \frac{5280\,V}{15 + C}$, N being the number of vehicles passing a given point per hour, V the velocity in miles per hour, and C the clearance between vehicles in feet.

Naturally the spacing between vehicles increases as the velocity increases, as a matter of safety. From observations on the Washington-Baltimore Road during special rush hours it was found that vehicles moving 10 to 15 miles per hour were frequently spaced as close as 15 ft. and groups moving 25 to 30 miles per hour averaged 50 to 60 ft. between vehicles. This and other evidence seemed to indicate that the spacing between vehicles varies approximately as the square of the velocity. If this is correct, then.

$C = \frac{V}{15}$ and

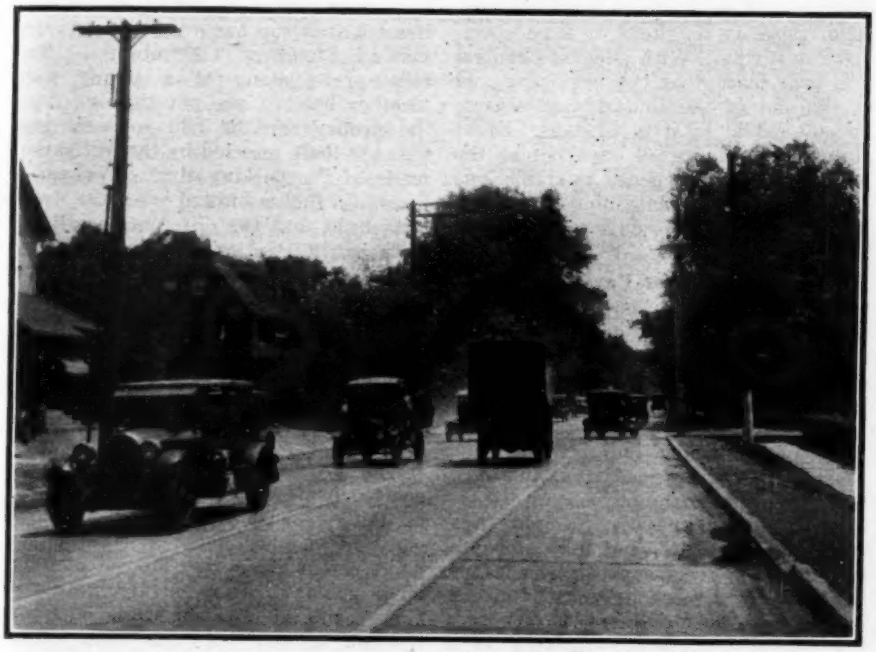
$$(2)\quad N = \frac{5280\,V}{15 + \frac{V}{15}}$$

To determine the maximum value of N, the first differential of this equation is equated to zero giving V a value of 15. This indicates that the maximum vehicle discharge will occur when the line of vehicles is moving at 15 miles per hour. (Studies by Col. Nathan W. MacChesney of Chicago show maximum actual traffic output at a speed of about 22 miles per hour.) For a single line of traffic averaging 15 miles per hour Dean Johnston's formula gives 2,640 vehicles per hour, or a total of 5,280 for a two-lane pavement.

Observations of actual traffic, however, do not seem to indicate such high results as obtained for theoretical

maximums. Observers stationed on this section of the Washington-Baltimore road reported uncomfortable crowding when single lane traffic reached about 1,200 per hour.

Pennsylvania Observations. — Observation made by the Pennsylvania Highway Department on a pavement along the west bank of the Susquehanna River across from Harrisburg also indicates that actual maximum traffic falls considerably under figures obtained by the formulas that have been developed. This particular highway was a two-lane pavement with a car line alongside. At peak periods the traffic survey, indicated that approximately 1,500 vehicles were carried. Based on these observations, a maximum of about 1,700 vehicles per hour was deemed possible.



Lincoln Highway in Wayne, Delaware County, Pennsylvania. A 40-Ft. Pavement

Mr. Kelker's Formula.—Mr. R. F. Kelker, Jr., of Chicago, has proposed the following formulas for determining road traffic capacities:

(1) $C = \dfrac{3600}{\dfrac{T+L}{S}} = \dfrac{3600}{\dfrac{T+12}{M}}$

As $\dfrac{T+12}{M}$ = time in seconds between center of cars, then

(2) $D = \dfrac{(T+12)}{M} \times \dfrac{(88M)}{60} = 1.467\,MT + L$

C = Number of cars per hour per lane.

T = Time in seconds between cars.

D = Distance in feet between car centers.

S = Speed in feet per second.

M = Speed in miles per hour.

L = Maximum car length = 17.6 feet.

He does not agree that the spacing between vehicles varies approximately as the square of the velocity.

Based on his observations at points of heavy traffic in Chicago, Mr. Kelker differentiates between the theoretical maximum vehicle capacity and the practical or "use" capacity in the following conclusions:

A. For theoretical maximum capacity:
   1. The output of an unobstructed single lane is upwards of 3,300 cars per hour.
   2. The speed of cars for this output is upwards of 25 miles per hour.
   3. The variation in output between 20 and 35 miles per hour is inconsequential.

B. For practical or "use" capacity:
   1. The output per lane per hour where, at points of heavy cross traffic a good system of control is installed, is upwards of 1,500 cars.

Conclusions.—The majority opinion of highway engineers and officials consulted by the writer considers 40 ft. as being the maximum desirable continuous width of pavement for our heavily traveled highways. Where this is not adequate for the traffic, parallel routes (not necessarily within a mile or two of the road involved) should be developed to handle the excess.

The following quotations are from the report of the "Committee on Highway Traffic Analysis" of the Highway Research Board rendered in December, 1925: "Investigations indicate that the 20-foot roadway is of ample width to provide adequate clearances between the sides of vehicles and the edges of the roadway, and between passing vehicles."

"The Committee concludes that 22 and 24-ft. roadways are not required for two lanes of traffic" . . .

. . . "The illustrative data submitted indicates that roadways of from 24 to 30 ft. in width are used as three-lane, two-way roadways. Unfortunately, however, traffic movements on the middle lane cannot be governed by a right-of-way regulation. Hence the use of three-lane roadways provides conditions under which accidents may frequently occur. The Committee, therefore, from the standpoint of encouraging design which will promote the safe utilization of highways, recommends the use of the four-lane roadway when the highway transport survey indicates that the traffic capacity of a two-lane, two-way roadway will be exceeded."

Bottle Neck Elimination.—Widening should not be considered until all bottle necks and other obstructions have been eliminated and adjacent roads are receiving their fair share of traffic. A two-lane pavement should reach a peak load of approximately 2,000 vehicles per hour of unsegregated traffic before being widened.

Justification of wide pavements should not be considered on the basis of constant efficiency. There are bound to be slack periods of traffic on our superhighways which is also true of our standard two-lane roads. Peak traffic should be the governing factor.

The writer believes that pavement widths up to 40 ft. are necessary and are the best methods of handling excessive traffic in many communities. However, the parallel road has its place in the dispersion of traffic and in the opening and development of more rural areas. Each specific problem requires individual study to accomplish its proper solution. No general rules can be laid down to cover all cases.

Expenditures Demand Consideration.—Highway officials should not be carried off their feet by the noisy and insistent demands for excessive expenditures on pavement widening programs in certain localities resulting in very unfair concentration of highway expenditures in a few districts to the neglect of just demands from other parts of the state. Actual traffic conditions as determined by a state-wide highway transport survey such as those conducted in Connecticut, Massachusetts, Pennsylvania, Ohio and also in Cook County, Illinois, should form the basis of plans for relieving traffic congestion. Only in this way can our highway funds be expended intelligently for this purpose.

We are not confronted by a theory but a reality. Traffic congestion is already threatening the progress of many communities.

Control of Construction Unit Costs Through Design

How the Designing Engineer Can Aid in Keeping Down Construction Costs Outlined in Paper Presented Jan. 11 at Convention of American Road Builders Association

By T. WARREN ALLEN
Chief, Division of Control, U. S. Bureau of Public Roads

The tremendous annual expenditure in United States for highway improvement, amounting to a little over a billion dollars a year for rural highways or approximately a billion and a half, including city streets, is ample warrant for intensive studies undertaken for the purpose of promoting greater efficiency and securing a greater amount of work for the expenditures made. Lines of such study which may be pursued with profit are location, design, and the management of construction; location, for the purpose of securing the shortest and best lines to serve a given section; design, to secure the best and most economical plan along this location on which to secure bids from contractors; and, third, the management of construction.

The proper location, design, construction and maintenance of highways are also far-reaching in importance, not only to the traveling public when considered from the vehicle operating standpoint, but, to communities, large and small, when considered from the standpoint of development, comfort and advancement. The purpose of this paper, however, is to discuss one phase of design that affects construction costs and these other allied subjects are referred to so that a vision may be had of the wider field highway engineers must occupy.

Cutting the Mixing Time.—In highway design more or less consideration is given to keeping down excavation quantities, but the problem is usually not given the consideration it warrants and the result is but a partial solution. It is not the purpose of this paper, however, to dwell upon this phase of design or the adverse effect on cost of poorly written specifications and unduly drastic inspection. One specification item, that of mixing time, may be mentioned. Some engineers specify one and a half minutes for mixing time of concrete, while others specify one minute, but a considerable number of field tests indicate that with the better designed mixers and adequate control over materials and water content, three-quarters of a minute of mixing will give a concrete of so nearly the same strength as a minute or a minute and a half that the extra cost of the longer mixing time does not seem warranted. Cutting the mixing time by this amount and keeping the mixer fully occupied are very important items in a cost reduction program. This may be more definitely expressed by stating that the maximum number of batches of concrete that may be turned out per hour with a mixing time of 1½ minutes is 34, for one minute 48, and for three-quarters of a minute 63, and that for a full working day of 10 hours the cost of paving is increased about $400 per mile of pavement laid for each one-fourth minute added to the mixing time. Unless recently changed, nine states require a 1½ minute mix, six a 1¼ minute mix, and thirty-three a minute mix. Also, there is the item of time specified for curing. With adequate control this time, except at the beginning and at the end of the construction season, may be cut at least to 14 days. Eight states now require 30 days before the pavement may be opened to traffic, one state 28 days, twenty-nine states 21 days, four require 20 days, one 18 days, three 14 days, and two 13 days.

More Attention for Pavement Loads.—Again, the items of proportioning and time of mixing are determined without giving much attention to the strength of the concrete needed to withstand the loads to come upon the pavement. The highway engineer should take cognizance of these and similar things, and constantly study the activities in which he is engaged for the purpose of discovering how they may be brought to a more efficient state, and take steps to introduce the necessary betterments. I believe that a more aggressive attack on the important problems confronting the highway engineer will also do a great deal towards enhancing his professional standing.

Let us now give consideration to another effect of design on construction costs, that of haul length. This is a matter of importance to all sorts of construction, but it seems to be of greater immediate moment in the grading field than in other phases of highway work. The first thing that strikes one in any extended study of the salient features of grading work is that it divides naturally into two distinct categories. There are, first, digging and loading, and, second, transporting. It is not of interest here to trace the line of demarkation down through such tools as the fresno and the wheel-scraper, though this can be done readily enough on a perfectly rational basis. Rather, in developing the effect of design on cost, it is better to take an equipment set-up where the demarkation is clear, as in the case of the elevating grader or the power shovel on the one hand and the teams and wagons on the other.

Costs Little More to Double Production.—A power shovel requires a given crew for its proper operation, no matter what output is being secured. Depreciation is not much affected by the amount of material handled during any given time. Even the amount of fuel used falls only slightly as the rate of production drops. The same condition is to be observed in the operation of a concrete mixer. The one man who runs the mixer cannot be cut to half a man if a batch is run out every 2½ minutes instead of every 1¼ minutes. The mixer runs along at a steady pace whether batches are put through it at the proper rate or not, so wear and tear are little affected by the utilization made of its working time. Perhaps a little less fuel is burned when the drum runs light, but the difference is slight.

These illustrations could be multiplied but to do so would be merely to add emphasis unnecessarily to the fact that in the highway field each piece of equipment generates an operating cost which is pretty constant, so much so, in fact, that if a contractor sends out a power shovel or a mixer or an elevating grader or even a plow or a fresno, he has for the job to which this equipment is sent added a fixed item of daily expense that is just about as constant and just about as rigid as the employment of another laborer at fixed wage per day. The contractor can discharge the laborer, but while he is on the job he will draw his wage every day he works. The contractor can also discontinue the use of the shovel but as along as it is in service it, too, will generate its regular cost every day it operates and constantly accumulate depreciation charges.

Basic Unit Production Cost.—Now, the limiting output capacity of any piece of equipment or combination of equipment and the operating cost of that equipment are the controlling elements in determining what may be called the basic unit production cost. To illustrate, let us assume that the output capacity of a steam shovel is 1,000 cu. yd. a day of a given kind of material, and that its operating cost in that material is $75 a day. There is not time enough available to develop here a justification for either figure. To do so would hardly be of value, but whether they are correct or not they will illustrate the theory involved as well as any. But if 1,000 cu. yd. per 10-hour day is capacity production for this shovel in the given material and

$75 is its proper daily operating cost, it follows that the basic unit production cost for loading this dirt with it is 7½ ct. a cubic yard. Moreover, this cost can only be reduced below this figure by reducing the daily operating cost, for in the nature of the case, 1,000 yd. per day being the full capacity of that shovel, output cannot be increased except by rebuilding the shovel, which, in fact, makes of it another shovel.

Wage Scales Affect Basic Cost.—The basic unit production cost will vary a little from place to place because differences between prevailing wage scales will somewhat alter the daily cost of operation. The cost of fuel also varies, as do the other items which comprise the daily operating cost. However, the greatest current differences in regional wage scales, in fuel costs, etc., though in themselves important, are not great enough to make it possible to establish any basis for the belief that such differences will cause the basic unit production cost on this particular work to vary more than a cent or two a cubic yard from the mean. The basic unit production cost is, of course, based on the correct use of labor, fuel, etc. It presupposes that the hauling equipment is so supplied and handled that no shovel time is lost. There is, therefore, little possibility of improving this basic production cost by modifying the personnel or the utilization of fuel, etc., on a given piece of equipment, but improvements in equipment do affect it.

Finally, as general economic conditions change, wage scales rise or fall and with these changes the value of commodities generally is somewhat altered. This naturally affects the cost of operation and so affects the basic unit production cost.

Efficiency Can Be Determined.—There are two points it is desired to bring out through this method of presentation. The first of these is that, for any given piece or group of pieces of equipment, there is for a given set of conditions a basic unit production cost which is the lowest unit cost obtainable with that machine or that combination of machines. To reach it requires merely that equipment be worked at full output capacity, properly manned and properly served. In short, it becomes a standard with which actual results may be compared and operating efficiency thus determined.

The second point is that, though the basic unit production cost is not a fixed thing, varying as it does from place to place and from time to time, the variations are relatively small for such equipment as power shovels, elevating graders, concrete pavers, etc. Regional differences in wage scales are considerable, but when these are applied to a correct personnel set-up for a piece of equipment of this kind, their effect on the daily operating cost is so small that the basic unit production cost is little affected. The same must be said of variations in economic conditions. These changes are important—that is true enough—but the commonly accepted engineering view that they are vital, for example, to low cost steam shovel or elevating grader production, can hardly be substantiated when the facts are analyzed in this fashion. Variations of 10 per cent, in some cases perhaps as much as 20 per cent or 25 per cent, are encountered, but it is not such variations as these that account, for instance, for the fact that there are regions in this country where grading for highway work commonly costs less than 20 ct. a cubic yard and that there are regions where it often costs over $1 a cubic yard.

Labor Wastes Not Serious.—Neither can such differences as these be sufficiently explained by the incorrect use of labor, fuel, etc., in such regions. Rather extended studies of highway construction practices do show that there is a good deal of variation between the correct and the actual use of labor, fuel, etc., variations which have the effect of making actual production cost higher than it ought to be. But such incorrect practices are not limited to the high cost regions. Therefore, these differences, like those to which reference has just been made, may be dismissed as relatively of minor importance, taking highway construction work as a whole and as it exists today. The man who uses an extra man on his shovel and pays him $4 a day increases basic unit production cost only a little more than 5 per cent. This is, of course, a waste which tends to reduce profit, but wastes of this sort are not the most serious wastes in the highway field.

Efficient Equipment Important.—To find the really serious wastes in most lines of our present highway work we must inquire not into the reason why one pays a little higher wages or uses more labor or more fuel than another, but we must turn our inquiry into such lines as will tell us why one man in one place consistently maintains his output close to the limiting output capacity of his equipment, while another in some other place, but, under reasonably identical conditions as to equipment and materials, rarely succeeds in maintaining better than 50 per cent of the limiting output capacity of his equipment. In short, the really important question in searching for lower construction costs in several important lines of highway work, therefore, is not the cost of labor nor the cost of the supplies, but why the production of our highly specialized equipment so seldom even measurably approaches its limiting output capacity. In other words, the cost of much of our highway work is fixed not by the output capacity of our equipment, but by the rate of efficiency with which this equipment is operated.

The Bureau of Public Roads has been studying this problem, both extensively and intensively, for some time, and as a result has come to the conclusion that there are a number of specific causes of low production. On the contractor's side of this problem, the first of these is the common failure to coordinate the capacity of interdependent equipment. On concrete jobs this is apt to express itself more definitely as a failure to provide enough transportation to keep the mixer supplied but it may be a failure to provide loading facilities which operate with sufficient speed or the use of trucks which dump too slowly, etc. There are a considerable number of points at any one of which a failure to coordinate may cause under-production.

Equipment Capacity Interdependent.—On elevating grader work and on power shovel work the failure to coordinate the capacity of interdependent equipment is apt to be a failure to supply enough hauling equipment properly to serve the digging units or to so operate the hauling equipment as to not interfere with the continuous operation of the digging units.

Another cause of low efficiency is undertrained operators. Very few shovel operators really know how to operate a shovel as it should be operated. Very few mixer operators operate the mixer correctly. The same is true of operators on other types of equipment. It is also true that neither superintendents nor contractors, as a group, obtain full production from even their most important machines, and most astonishing of all, that even the manufacturers of these machines seem not to know their productive capacity or how to obtain it. This is merely a statement of fact.

Job layout is another important cause of low efficiency. If the equipment is not properly arranged and the general scheme of handling it properly worked out, top-notch production is impossible.

Length of Haul.—On the engineering side—and this is the matter with which we are most concerned at the moment—an outstanding cause of low production is the length of haul as fixed in the design of the work. In the case of the power shovel used as an illustration, we noted a daily operating cost of $75 and that this was a pretty constant figure—a cost that held good whether much material was dug or little. On the other hand, it will be apparent that the number of teams required in order to transport the material which this shovel could dig would vary with the distance it must be hauled. The Bureau's studies show that teams travel about 250 ft. a minute. These studies also show that such matters as waiting while the load

is put on at the shovel, turning at the shovel, turning at the fill, dropping the load, etc., should not require more than two minutes per load hauled. If, then, the distance the dirt must be hauled is 250 ft., a load can be hauled every four minutes. If the shovel can put a dipperful of good common excavation onto a wagon every 20 seconds—as most shovels can if properly operated, two dipperfuls making a wagon load—a wagon can be loaded every 40 seconds, so to keep the shovel supplied with wagons a train of six wagons (4 times 60 or 240 seconds divided by 40 seconds or six) is required. If, on the other hand, the haul distance is 500 ft. the round trip for the wagons becomes six minutes and nine wagons (6 times 60 or 360 divided by 40 equals 9) must be supplied. At 1,000 ft. the round trip time becomes ten minutes and 15 wagons are needed to keep the shovel busy all the time. At 2,000 ft. 27 wagons are required, and at 4,000 ft. 51. But while hauls as long as 2,000 ft. are common enough in grading work and hauls of 4,000 ft. or more are by no means unknown, it will be perfectly obvious to anyone that no ordinary grading project involves the consistent use of such hauls. On all ordinary jobs the haul varies in length from cut to cut and from day to day, frequently from hour to hour. Generally, however, the amount of material having either very long or very short hauls is a relatively minor part of the total.

Must Be Ready for Maximum Haul.—But, if the highest production is to be maintained throughout the work all the transportation needed to meet the longest haul must be supplied. In other words, if a job calls for a maximum haul of 1,000 ft. the contractor must have 15 wagons available or it becomes impossible for him to maintain the highest production at all times. If the haul is 2,000 ft. he must have 27 wagons; if it is 4,000 ft. he must have 51 wagons. Otherwise, production will at times unavoidably be below the output capacity of the digging unit. Naturally, if the haul was all of the same length the contractor could be expected to provide a full wagon train merely as a matter of self interest, but in practice it never is all of the same length. As a result, what the contractor does is to furnish a wagon train which harmonizes with his understanding of haul requirements as he has previously encountered them. Usually this means that he will send out for an ordinary power shovel or elevating grader job from six to ten wagons or a somewhat equivalent number of trucks. If we assume that the cost of maintaining a team and wagon with driver is $7.00 a day, which appears to be a fairly representative figure, and that ten wagons are sent out with the shovel, the daily cost of operating the wagons is $70, so the total production cost—shovel and wagons in the illustration previously used—becomes $145 a day. Ten wagons can take all of the diggings from the shovel as long as the haul is under about 600 ft. but beyond that distance the hauling equipment is insufficient and production falls. There is a production capacity so far as the loading unit is concerned, of 1,000 cu. yds. per 10-hour day, but at 1,000 ft. production has fallen to 67 per cent of the possible maximum because there is not enough transportation to handle what the shovel can produce. At 2,000 ft. production is at 37 per cent of shovel capacity and at 4,000 ft. is under 20 per cent. And, it may be observed, the unit cost of handling the dirt has been affected in inverse ratio. Up to 600 ft. it was a little under 15c. At 400 ft. it had risen to about 75c. If, on the other hand, the contractor had sent out only six wagons, his daily cost of operation would have been only $117 but the highest production could have been maintained only as long as the haul was under 250 ft. At 1,000 ft. production efficiency would have fallen to 40, at 2,000 ft. to 22, and at 4,000 ft. to under 12, while unit production cost, though only 12c at 250 ft., would have been about 30c at 1,000 ft., about 55c at 2,000 ft. and $1.00 at 4,000 ft.

Long Hauls Uneconomical. — Of course, in each individual case the problem of what, in fact, is the most economical outfit to use on a given job is one that is easy enough for you as engineers to solve on the basis here suggested, but this is not the point I wish to leave with you. Rather, the point of importance as contractors are at present equipped is that long haul means low production and so is astonishingly and unavoidably productive of high cost. Indeed, long haul may easily become so expensive that it is as important an element in cost as solid rock. Often it is more destructive of economy in operation than loose rock. The matter is put in this way because you are all familiar with the manner in which alignment and grade are modified in order to avoid work involving classification. This is perfectly proper. A good engineer ordinarily can avoid much of the rock, both loose and solid, that an engineer of less experience would perhaps think it necessary to take out. Economy dictates the avoidance of heavy work of this kind if the avoidance can be accomplished without injury to the general value of the road. This we all recognize and as a matter of everyday practice, observe.

But if this is a correct statement as applied to loose rock and to solid rock, it certainly should be equally our practice as applied to long haul, for the effect of long haul on cost is quite as disastrous and should be quite as apparent as the effect of rock. While in the case of rock work, avoidance sometimes is impossible and when not impossible may still be inexpedient because of the effect of avoidance on grade and alignment or both, conditions really demanding the use of long haul are much less likely to arise, because borrow and waste often can be restored to when long haul otherwise might be required, and the design should definitely provide for this where practicable. You have all had requests from contractors to substitute borrow and waste for longitudinal haul. If this method is justifiable it should be definitely provided for in the plans, estimates and specifications used by bidders and not instead given as a privilege to the successful bidder.

Cheaper to Borrow and Waste.—It must have been apparent as the effect of haul on cost was outlined a moment ago, that with the ten team outfit it cost less to haul 2 yds. of material anywhere within a 600-ft. limit than it did to haul 1 yd. beyond about 1,500 ft. With the six team outfit it cost less to haul 2 yds. anywhere within 250 ft. than it cost to haul 1 yd. 800 ft. These facts will suggest at once that as contractors are equipped, it is cheaper to borrow and waste, if the design can be adjusted in no other way, than it is to use long hauls.

In this connection it may be stated that there is no more delusive thing in highway engineering practice today than the so-called "free haul." As a matter of fact, there is no such thing as "free haul." Every bit of hauling is an expense to the contractor. The more hauling there is the more it costs him to do the work. It is quite true that he may overlook the effect of long haul in entering his bid and so may have to pay this extra cost out of his own pocket, but I am quite sure that none of you desire such a result. But the fact that so many grading contractors fail should be evidence enough, particularly in view of the high cost of long haul as outlined to you just a moment ago, that long so-called "free hauls" with the wide variation they permit in the amount of hauling actually required from project to project tend to destroy contractors.

Keep Haul in Reasonable Bounds.—The obvious conclusion from these facts is that the objective of the designing engineer should be to keep all of the haul within such bounds that the ordinary contractor using a reasonable equipment set-up can maintain a high rate of production. It is only in this way that he can do the work at a reasonable cost. In short, he cannot work economically if you, as an engineer, have destroyed the possibility of his maintaining a high operating efficiency by producing a design that does not fit in with existing equipment set-ups and current construction methods. And we all know only too well that high cost to the contractor due to any of these methods is inevitably, sooner or later, reflected into the bid prices and the cost the public pays for the completed work.

I shall lay no great emphasis on the details of so preparing plans that

economical construction will result. The careful scrutiny of a considerable number of plans with the facts which have been presented to you in mind, has developed the impression that more thought is now given to whether a balance between cut and fill is secured than to whether the haul established will make the maintenance of a high average in production possible, actual construction conditions as they really are being considered. A series of alternate long hauls followed by short hauls is destructive of economy in construction. On the short hauls the teams work at less than full capacity, and on the long hauls there are not enough teams. This is just as true for truck hauls as for team haul. Sometimes merely shifting the balance points in the cuts so that haul in both directions from the cuts is equal will convert a very poor design into a reasonably good design, at least so far as the actual cost of doing the work is concerned. Sometimes a grade must be raised, sometimes lowered, or the gradient may have to be adjusted. All of these are devices to which you have had frequent recourse. And they will continue to be the devices used to create a satisfactory design. The thought I desire to leave with you is that by the proper use of such devices as these it is possible almost entirely to avoid hauls of over 1,000 ft. and to keep the great bulk of the hauling within 700 ft. Where this is done in the original design, the contractor can maintain a high rate of production with an ordinary outfit and the practical result is grading work at a reasonable cost.

Road Builders Are Public Servants.—We are, all of us, the servants of the public. Our work is the creation of a public benefit for which the public pays. Our duty is to create as economically as possible. There is, therefore, in the situation just discussed more than a matter of professional proficiency. There is, in fact, the matter of our obvious duty to the public we serve. Where there is waste it must be discovered and stopped. Poor design is followed by pure waste. The duty which rests on us to take more heed in this matter needs no other emphasis.

Cost of Highway Plans in South Dakota

The cost of preparing plans for state highway work in South Dakota is approximately 1 per cent of the completed cost of construction. The following note from the annual report of the South Dakota Highway Commission for the period ending June 30, 1926, gives some details of the work.

Plans are prepared for all state highway construction showing location, length, type, grade, structures and excavation in detail, from which bids are received by units. The plans are prepared from survey notes and are a very detailed tabulation of all work necessary for the complete construction of any project.

During the past fiscal year 654.37 miles of plans were made at cost of $29,179.29 or average cost of $44.59 per mile. 414.40 miles of federal aid plans were made at average cost of $46.62 per mile—204.51 miles of state aid plans were made at average cost of $39.30 per mile—35.46 miles of county plans were made at average cost of $51.43 per mile. Plan revisions were made costing $7,694.81, which are charged to construction engineering.

To date 4726.86 miles of plans have been prepared at cost and $180,483.60 or at average cost of $38.18 per mile. Plan revisions were made costing $32,398.19. A total of 3543.77 miles of plans have been prepared for federal aid at average cost of $44.71 per mile. A total of 1087.78 miles of state aid plans have been prepared at an average cost of $17.29 per mile. A total of 95.31 miles of plans were prepared for county construction at an average cost of $33.92 per mile.

New Twin Type Trailer Bin

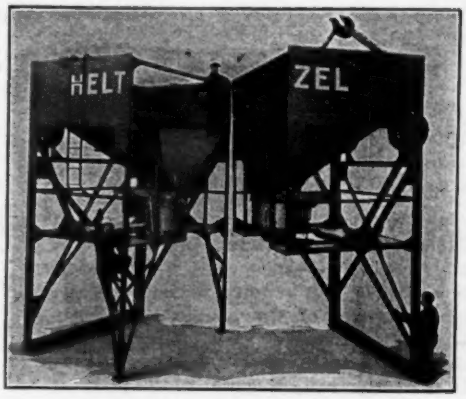
A new bin having many new features has been brought out by The Heltzel Steel Form & Iron Co., Warren, O. The construction of the bin in general consists of 80 and 105-ton bins cut squarely in the middle on a perpendicular line, each half having its own trailer wheels. In erecting, temporary legs are fastened to one of the halves and it is stood upright with a crane. The other half is then lifted with a crane and the two halves securely fastened together with 40 bolts. The temporary legs are then removed and the outfit is ready for the first batch.

When in trailing position, each half is stated to be no larger than a standard 35-ton trailer bin and can be trailed by truck through congested street traffic at a speed of from 10 to 20 miles per hour.

The principle idea of the bin construction is to avoid the difficult handling and erection of large capacity bins.

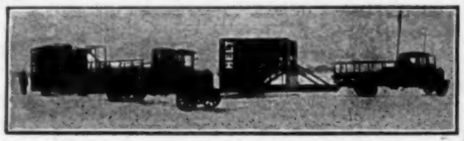
The agrabatcher arrangement is stated to be just as revolutionary as the bin construction. Agrabatchers are supplied for measuring materials either by weight or volume. In each case, one man located on a Trilok self-cleaning, steel grating platform, which completely encircles the agrabatchers 8 ft. 3in. above the ground, performs the complete operation by an easy turn of a wheel control. This is accomplished by a wheel, rack and pinion method; the operator being located above the track where he can see that all conditions are right for dumping and that the agrabatchers are OK.

The weighing and measuring agrabatchers are interchangeable, using the same frame and bolt holes. Weighing agrabatchers are simple and accurate. The trip is automatic and standard modified beam type of scale is used with two point suspension and equalizer; hence it is not necessary to level the scale. To prepare for operation, when bin is first set up, simply balance the scale beam. The turning of a single wheel control performs the complete operation of filling, cutting off, dumping the batch of sand and stone, opening the upper gates and closing the lower gates in less than 10 seconds.



Heltzel New Twin Type Trailer Bin

An agrabatcher adjusting device has also been designed, to be supplied on order, which consists of a bevel gear set and rear chain and sprocket design; and here, also, the operation of a single control wheel raises or lowers the agrabatcher simultaneously on all four supporting bolts, eliminating the need of operating each one individually by wrench or by hand.



Moving a Bin

Over 22,000,000 Motor Vehicles in Use in 1926

Motor vehicles in use in the United States now exceed 22,000,000, or one to every five persons, according to annual registration figures in the magazine, Motor. Passenger and commercial cars total 22,342,457, a gain over 1925 of 2,254,000, or 11.2 per cent. While the gain is 2.7 per cent less than the gain of 1925 over 1924, this is due to the fact that an unprecedentedly large number of vehicles were taken out of service, the magazine says. Commercial vehicles now number 2,876,781, a gain over the preceding year of 421,688, or 17.1 per cent. Passenger automobiles numbered 19,465,676, an increase of 1,831,793, or 10.3 per cent over the previous year.

The Highway Situation in Mexico

What Is Being Done in the Southern Republic Outlined in Paper Presented Jan. 12 at 24th Annual Convention of American Road Builders Association

By ANDRES ORTIZ

Engineer, Department of Communication, Republic of Mexico

Mexico, as far as highways are concerned, is still in its infancy. It was not until 1925 that the Mexican Government with great enthusiasm started a definite program to give the country a system of modern highways.

Work has been begun on a solid basis, filling a great national necessity, and I am glad to say that it has taken place with the whole-hearted support and approval of the people of Mexico. In view of this we expect road building in Mexico will increase in the proportion of the rolling snow ball and that within a few years our immense and wonderful resources, unique in the world because of its great variety of raw materials necessary for modern industry, will be fully exploited in order to better the economic and social condition of our people.

The program of the work has been based on the taxation of gasoline and tobacco, which at present amount to about one-million pesos per month. Congress recently passed the National Highway Law, which authorizes the Federal Government to issue bonds for the construction of highways, when it is deemed convenient to do so. In my opinion, I feel that our highway work should be based fundamentally on the funds available from these taxes, and increase the work progressively as the revenue of said taxes increases with the experience and training, we are now acquiring.

Spent 13,500,000 Pesos.—During 1925, the first year of extensive road building in Mexico, the Government spent thirteen and one-half million pesos, which corresponds to about 4.4 per cent of the total Federal Budget, while the American Federal Government spent during 1925, only 3 per cent of the total Federal Budget. I base my opinion on these figures when I say that our Federal Government has started to build an elaborate network of highways in Mexico.

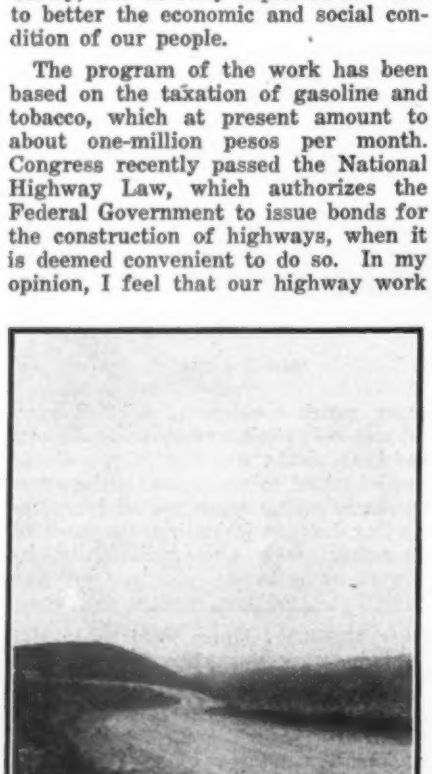
Unfortunately, the same cannot be said about the states and municipalities of the republic, which in the United States help support the cost of highway construction. However, we hope that they will soon follow the example of our federal government.

The Federal Highway Commission of Mexico, created to promote the construction of national roads in the country, bought machinery for approximately three million pesos, being equipped now with machines of various types and sizes which will efficiently build and maintain our roads. All the machinery that is at present used in Mexico is of American make and bought after careful selection of the best manufacturers. I desire to call your attention to the fact that the American engineers who worked with us were greatly surprised about the ability and quick adaptation of our laborers and mechanics, who after 30 days could run any type of tractor, grader, steam shovels, distributors, drillers, with praiseworthy efficiency.

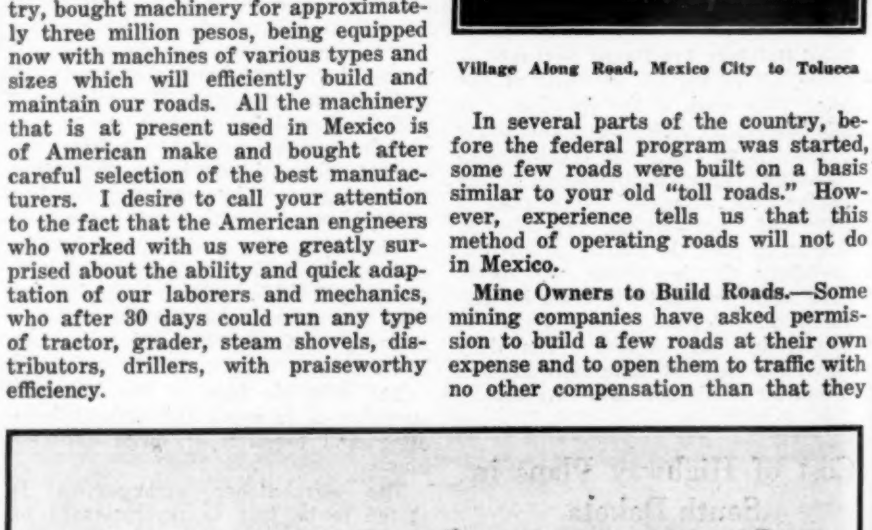
Village Along Road, Mexico City to Tolucca

In several parts of the country, before the federal program was started, some few roads were built on a basis similar to your old "toll roads." However, experience tells us that this method of operating roads will not do in Mexico.

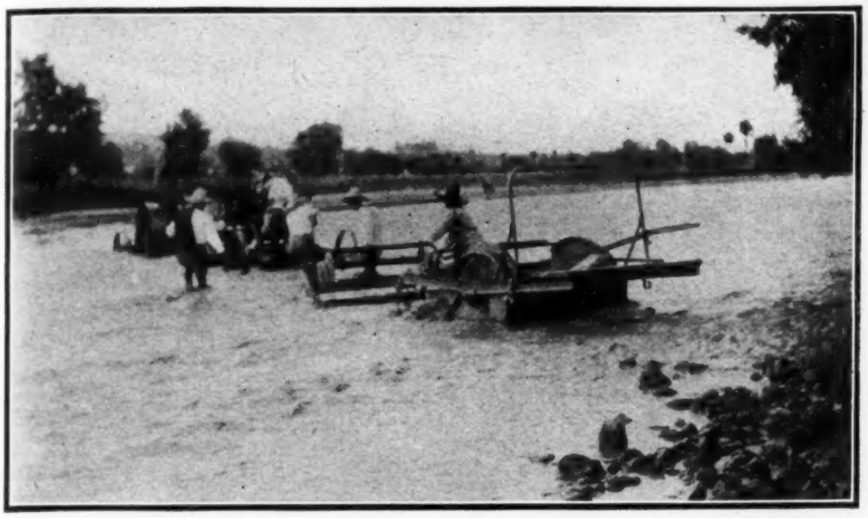
Mine Owners to Build Roads.—Some mining companies have asked permission to build a few roads at their own expense and to open them to traffic with no other compensation than that they



View of Mexico City-Tolucca Road



Elevating Grader Work on Mexico Gulf Road in State of Tampico



Crossing River in State of Tlaxcala with an Aurora Grader and Tumblebugs

may have a means of transportation for their products. All they have asked for is traffic regulations that will allow proper maintenance.

In regard to this we have begun a system of construction and operation that I believe will greatly help road construction in our country. A firm, or a group of firms, operating in a certain isolated region proposed to furnish sufficient capital for the building of a road. These companies pay annually before the construction of the road an amount of pesos for taxes. When the construction is finished they are in position to increase their bulk of operations, which will, of course, increase the taxes to, let us say, A plus B pesos. The difference, B, during a certain number of years, in accordance with the contract, is then used for the payment of the capital invested in the building of the road and interest on same. This method is very feasible in Mexico, where many good roads are absolutely necessary in order to export rich minerals as well as many agricultural products yet unexploited.

Work On Cost Plus Basis.—During the first year of highway construction we worked on the cost plus basis. We know that this method is neither the more economical nor the more convenient, but its adoption was justified then, since it was urgent that work be started as soon as possible, due to the great number of laborers unemployed who would not stand for the further delay occasioned by arrangement of plans, estimates, specifications, etc.

Now while constructing the Puebla and Pachuca roads, of which I will speak later, and a few stretches of the Toluca, Acapulco and Monterey roads, the final location of these two last roads was completed, as well as the specifications for roads and bridges made especially to adapt themselves to our materials, climate and traffic.

The federal highway commission is now in a position to continue the work under better circumstances and no doubt will adopt construction under unit prices.

Traffic Increases.—The increase of traffic on the roads recently built has been surprising. Such roads as the Puebla that before reconstruction had only a traffic of 10 vehicles per day, have now reached 1,000 vehicles daily, counting automobiles, trucks and busses; besides this there is a constant tendency for traffic increase. A traffic count has been established in order to determine the type of wearing surface required for our roads. In order to avoid confusion in traffic produced by local regulations, the Government has ordered a Federal Traffic Regulation to be inforced throughout the whole Republic by the Federal Highway Police and local authorities.

In Mexico, especially in the Great Central Valley—Mesa Central—bounded to the East and West by mountains, there is a great variety of construction materials of very good quality that can be used in road building. The group of volcanoes in our territory, such as the Ceboruco on the west coast; Popocatepetl, Ixtlazihuatl, Sleeping Lady, Ajusco, Nevado de Toluca on the Central Valley; La Malinche, El Cofre de Perote, and El Pico de Orizaba on the East coast, contain many deposits of volcanic rock and ashes that have been used to good advantage and economy in our work.

Composition of Sub-Grade.—Our soil is formed principally of tufas of sedimentary formation, formed by accumulation of fragments of volcanic rock washed out. Some of these tufas are known as "tepetate" and correspond to the type of porfidic tufas and pomosa tufas, having as principal elements sands, aluminae, carbonates, feldespates and water; some "tepetates" have as high as 70 per cent of sand. From this it can be seen that "tepetate" is a mixture somewhat resembling sand clay formed by Nature and which makes a splendid wearing surface for roads. Our "tepetate" roads have been surface treated with asphaltic oils with best results and have resisted traffic of 1,000 vehicles per eight hours.

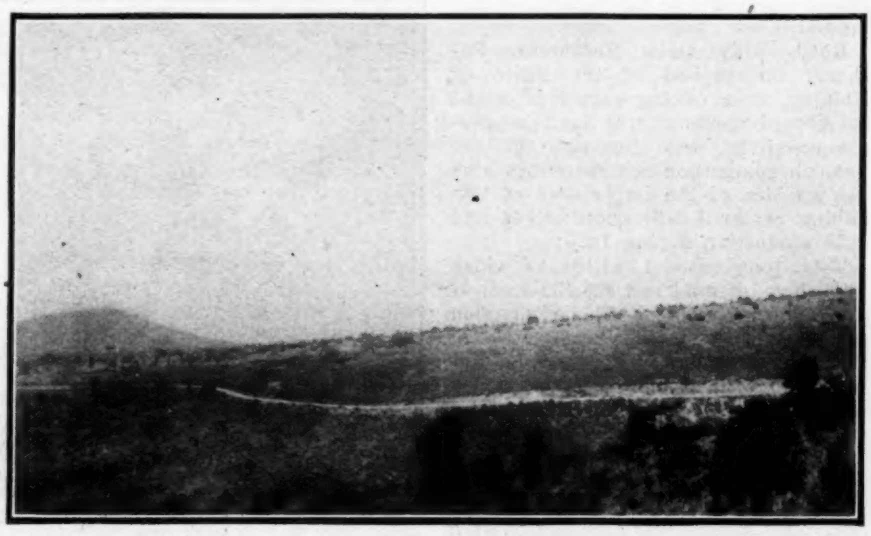
The wearing value of the "tepetate" varies with its composition, but in general allows grading, once scarified, with such heavy machines as the Rip-Snorter, or else using first a heavy scarifier and then the grader.

On the Pachuca road we used for grading units a "Best" 10 ton h.p. tractor and an Austin Rip-Snorter road machine. In a great many instances it was sufficient to drag the road in order to consolidate it, or compact, and only on a few stretches rollers were used.

Secondary Roads.—"Tepetate" roads, protected with asphaltic oil treatment and well drained, will undoubtedly be the solution for a second class road for the great central valley of Mexico.

We have also heavy asphaltic oils available that contain from 65 per cent to 70 per cent bitumin soluble and carbon bisulphide, which have given splendid results especially for the construction of penetration macadam.

The construction program for 1927 of



View Showing Alignment of One of the Mexican Highways

the Federal Highway Commission, presided over by Antonio Madrazo, is to first finish the Mexico-Acapulco and the Mexico-Laredo roads; this last one will be a connection of the American Highway System, forming the Mexican link of the Great Meridian Highway at Laredo, Texas.

The construction program during 1926 was carried out as follows:

The Mexico-Pachuca road, which is the first 93 kilometers link of the Mexico-Laredo road where work was started early in 1926 was opened to traffic on the 5th of September.

The first 27 kilometers were built on flat country, having a cross section of 10 meters; 6 meters for the surface and two meters for each shoulder. The surface is of water-bound macadam treated with Catchinite asphaltic surface.

From K.27 to K.93, the typical section is 10 meters wide, surfaced with "tepetate." The maximum gradient is

A Road to Be Graded in State of Tlaxcala

Road Grading in State of Oaxaca

4 per cent and only in a very few places. The rest of the road is on flat ground.

Roads May Open Resources.—Pachuca, the capital of the State of Hidalgo, is a mining center of great universal importance. It has been producing silver since the time of the Spanish domination and merely to give you an idea of the importance of this mining center I will quote silver and gold production during 1925:

Total tons mined 1,984,404, of which 4,402 Kgs. of gold and 828,130 Kgs. of silver were extracted. This production corresponds to the mines of El Chico, Pachuca, Real del Monte and Le Reforma that have now been connected by a modern highway with the capital of the Republic.

From K.27 at Venta de Carpio, a branch road has been built to the famous Pyramids of San Juan-Teotihuacan. This stretch was also located on a flat country which allows gradients less than 4 per cent and curves with minimum radius of 40 meters. The cross-section is 10 meters wide including shoulders. The wearing surface has been built of "tepetate" mixed with volcanic cinders or ashes which has proved to be an excellent combination. On this also asphaltic treatment will be applied.

Famous Scenic Regions.—The importance of San Juan Teotihuacan is mainly due to the archeological zones of Teotihuacan, located at the northeast of the town of the same name. The Pyramids of the Sun and of the Moon and the Citadel form a group of prehistorical monuments of great interest to the tourist and scientific people. Their surrounding mystery, their correct form of construction and alignment is an eloquent demonstration of the advancement and civilization of the people that built them, whether with sacred purposes or merely to have advanced strategical points for protection. The fact that the pyramids are trun-

Knocking Off Edges of Hand Made Square Cut Ditches in State of Oaxaca

cated shows that at least they used them as temples to worship their gods.

It would be a long task to try to describe the diversity and beauty of the archeological zone of Teotihuacan. Many good books have been written on this subject and thousands of tourists visit them!

As I said before, the Mexico-Pachuca road is the first link to the Mexico-Laredo road, which, after being built, will be the gate for American tourists to come, see and admire our beautiful antique monuments.

Mexico-Puebla Road.—The Mexico-Puebla road connects two of the most principal cities of the country; it has a length of 135 kilometers versus 210 kilometers of the shortest railroad line between these two cities.

On the way out of Mexico City the road has a boulevard section of 8 meters paved surface, and 4 meters of shoulder. The 35 first kilometers are located on level ground, with very ample curves, going through many small towns of the State of Mexico and through a very rich agricultural region.

From K.35, Zoquiapam, to K.91, San Martin Texmelucan, the road was located through very steep mountains, having a cross-section of 5½ meters paved surface and 1 meter of shoulder. The average maximum gradient is 6 per cent, but there is a little stretch where it is 7.8 per cent.

From K.97 to K.135 the road again was located through a very light rolling country and flat ground, going through towns of importance such as Huejotzingo and Cholula, of great historical importance.

The first 57 kilometers have been built of macadam treated with asphaltic oils and the rest of the road has a wearing surface of local materials, such as "tepetate" and sand-clay, which are now being treated with the asphaltic treatment known as "Catchinite," using preferably Catchinite processes No. 1 and No. 2.

The Mexico-Puebla road, of great commercial importance for the region it crosses, has also many charms for tourists of both towns. The mountainous section of this road, located at the slopes of the Ixtlazihuatl volcano—Sleeping Lady—has the most beautiful and varied panoramas of the Mexico and Puebla valleys, as well as in the mountain region itself, with the Ixtlazihuatl and Popocatepetl volcanos as principal attractions.

We consider our road program not only National, but Pan-American, and even international, and especially tending to a good understanding between neighbors of the North and of the South.

What more could be expected than better mutual intelligence and understanding between Mexico and the United States, Mexico and Central America than the construction of highways which allows such close relations and daily interchange as that, for instance, enjoyed today by the United States and Canada?

One thing that we must sincerely hope to achieve with our highway program is to make our relations better and closer with the great American people.

Downward "Kick" of Wheels in Starting

When a vehicle, at rest on the highway, starts, what is the measure of the effect on the pavement of the changed condition of rest to motion? The configuration, mass, and acceleration of the vehicle, obviously, determine the answer. Doubtless the answer would be given qualitatively, for it is believed that no quantitative measurements have ever been made. Qualitatively one would say that the pavement does not suffer in the slightest. It is not known that any highway specifications account for this specific force. But it is conceivable that the increase in the size and weight of motor trucks and the increasing number of quick-starting taxicabs, may make a quantitative answer desirable. Some interesting information on this subject is given in the December Public Roads by Thomas K. A. Hendrick of the Highway Research Board. Experiments were made by Mr. Hendrick along lines suggested by Prof. C. J. Tilden, chairman of the department of engineering mechanics, Yale University, on a bicycle, 3 Buick cars, 3 motor trucks (5 to 13 tons gross weight), and 5 taxicabs. The measurements were made by means of Toledo scales whereon the increase of force can be read directly from the dial scale as the indicator advances.

How the Experiments Were Made.—For the bicycle, the 550-lb. scale, in the Sheffield laboratory of engineering mechanics, Yale University, was used. Through the courtesy of the Connecticut State Highway Department, the 40,000-lb. scales located at West Haven, Conn., were used for automobiles, trucks, and taxicabs. All measurements were made with the rear wheels only on the platform of the scales.

When a vehicle is started from rest, according to D'Alembert's principle of reversed effective forces, there is applied at the center of gravity of the mass accelerated, as a result of the inertia of the vehicle, a reversed effective force equal to the mass times the acceleration and opposite in direction to the direction of motion. This reversed effective force, when added to the system of external forces, produces an imaginary condition of static equilibrium in all the forces acting on the vehicle. For this condition the laws of static equilibrium, $\Sigma H=0$, $\Sigma V=0$, $\Sigma M=0$, rigorously hold.

Applying the principle of the summation of moments about the point of contact of the front wheel, as a point of moments, it is readily seen that the reversed effective force causes a downward thrust or downward "kick" on the rear wheels, and an uplift on the front wheels. This downward "kick" was registered in the experiments made on the dial of the scale by the rapid advance of the indicator. The difference in the reading before and during starting measures the downward "kick" in pounds.

It is important to emphasize that this registration of the downward "kick" in pounds on the dial of the scale is independent of the acceleration and the location of the center of gravity in so far as it is not computed from these quantities. It is, in itself, a direct measurement of the downward "kick."

Results of experiments.—For each of the vehicles experimented with, 20 readings were made except in the case of the bicycle for which 21 readings were made. Each reading represents a separate, independent start, and the average of the readings was taken as the "kick" caused by each vehicle. The start was a normal start except in the case of the Buick 6-cylinder car. By "normal start" is meant that the vehicle was started as one would normally start on getting into a car on the highway and driving off. The drivers were experienced, their experience ranging from one to five years. The gasoline was controlled by foot accelerator except in the case of the Buick car, above mentioned, in which it was controlled by the throttle which was opened to the position necessary for a speed of 35 miles per hour on a level road.

As a result of the tests, it is believed that it can be stated that the downward "kick" of the rear wheels of vehicles, in starting from rest, varies according to the type and classification of the vehicle from 4 to 23 per cent of the load on the rear axle; and from 2 to 11.8 per cent of the total load.

For light passenger vehicles, with about 1,700 lb. on the rear axle and 3,200 lb. total weight, the average downward "kick" is about 6.4 per cent of the load on the rear axle or about 3.4 per cent of the total load.

For trucks with a total weight of 2,000 lb. 13,000 lb. on the rear axle, the downward "kick" is about 5.3 per cent of the load on the rear axle or 3.2 per cent of the total load.

For taxicabs, with a total weight of 3,500 lb., and a weight on the rear axle amounting to 1,900 lb., the downward "kick" is about 18.2 per cent of the latter or about 9.1 per cent of the total load.

In some cases, depending upon the load and body characteristics of the vehicle, and the idiosyncrasies of the driver, the downward "kick" of the rear wheels of some passenger cars may easily be one-fourth of a ton and for heavy trucks it may easily be one-half ton.

Progress in Sub-Grade Soil Investigations

What Is Being Done in Laboratory Research and in the Field Outlined in Paper Presented Jan. 13 at 24th Annual Convention of American Road Builders' Association

By FRANK H. ENO

Professor of Municipal Engineering, Ohio State University, Columbus, O.

Road engineers in America have known ever since road building began in this country that drainage—surface, side and under drainage—is a very important factor in the life and usefulness of the pavement. Surface and side drainage have been thoroughly understood and fairly well applied, but subdrainage, both beneath the pavement and along its sides, has been imperfectly understood and less perfectly applied.

Outside of marl beds and peat bogs, there are very few soils indeed, but that would give ample support to roads under any reasonable traffic load, provided the sub-soil could be kept free from an excess amount of water. While engineers undoubtedly have long realized that they were not securing perfect results in sub-drainage, they certainly have not realized that a more intimate knowledge of soils was necessary before there was any hope of securing better drainage results.

It has not been until the last six or seven years that any concerted and sustained study has been made of subsoils with the idea of improving the drainage and bearing value of the road sub-grade.

Soil Information Was Centralized.—In this country, practically all specialized knowledge about the soils was confined to members of the Bureau of Soils of the U. S. Department of Agriculture, excepting perhaps some facts about the status bearing value of soils gained by engineers and used in determining foundation footings for static structures, and a quite extensive study made by Professor C. M. Strahan, of the University of Georgia, to determine soil characteristics with reference to the best admixtures of sand and clay soils for sand-clay roads. Professor Strahan began the work in 1907 and published the results in a bulletin issued by the University of Georgia in June, 1922, entitled "Research Work on Semi-Gravel, Top Soil, Sand Clay and Other Road Materials in Georgia."

One of the most forward looking articles upon the effect of the water content of the sub-grade soil is published in the July issue of "Public Roads," 1918, by E. W. James, General Inspector, Bureau of Public Roads, in an article entitled "Drainage Increasingly Vital." Mr. James there discusses capillarity, water content of sub-grade soils, the necessity of French drains, raising the sub-grade above the water table, changing pavement sections to meet the increased danger from varying soil conditions, and other pertinent questions.

The U. S. Bureau of Public Roads began some soil tests in 1919 in connection with the investigation of the distribution of pressures through earth, but it was not until 1920 that general activity in sub-soil research was initiated, when the Federal Highway Council at its Philadelphia meeting on February 24, 1920, appointed a committee on "Sub-grade and Its Relation to Road Surfacing and Traffic," with General Coleman Du Pont as Chairman. The work of this committee was afterwards absorbed by committees of the Highway Research Board of the National Research Council.

Beginning of Bureau Activity.—"Public Roads," for April, 1920, notes the actual beginning of soil investigations by the Bureau of Public Roads for the purpose of determining the various soil characteristics and the classification of soils. Later, in July, 1920, the Bureau joined with the California Highway Commission in making a very thorough investigation of the California highways, in which much valuable data was collected relative to the failure of roads over adobe and heavy clay soils in that State. It was found that about 70 per cent out of 157 miles of concrete pavement laid upon adobe soil had suffered serious deterioration.

The sub-soil survey inaugurated by the Ohio Good Roads Federation in February began work in May, 1920, so that by July of that year three important sub-grade soil investigations were under way.

Outline of the Work.—It was realized at the first conference of the original committee that the first great problem was the formulation of some definite method of classifying soils so that soil investigators and road engineers interested in sub-grade soils might have a common ground of understanding. The classification system used by the European soil scientists was largely developed in soil investigations for the agriculturist and were all too indefinite to meet the engineers' requirements.

Some classified soils on a chemical basis, as silicate, carbonate, and sulphate soils, with their various sub-divisions. Others classified as residual, transported and alluvial soils, with subdivisions according to the parent source as quartzite, granite, basalt, etc.

Thaer used texture as a basis, more nearly like the U. S. Soil Bureau, as sand, sandy loam, loam, clay and the like, but his sub-divisions were related to the quality of the soil for growing grains, as rich wheat, strong, poor, thin wheat soil or similarly with oats or barley soils.

Glinka (Russian) proposes six general classifications of soils based upon their development under certain moisture conditions, and further sub-divided into classes by their color, composition or position of formation. His general classes are of soils developed under optimism, average, moderate, insufficient or excessive moisture conditions and sub-classed as Laterito, Terra Rosa, Podsol or ashy soils and the like.

The method used by the U. S. Bureau of Soils is to classify the soils as coming from certain climatic or geographic regions, such as the Piedmont Plateau soils, or those from the Atlantic Coastal Plain, or the Arid South West or the Limestone Valleys and Uplands.

The soils are then further classified into series as to the local place where they were first studied, as the Wooster, Trumbull or Miami series—so named from the points in Ohio where they were first studied by the Soils Bureau. The final classification is based upon texture, as sand, sandy loam, silty clay, or clay soils. A given soil would be termed, say, as Iredell clay loam from the Atlantic Coastal Plain and might be found anywhere from Maryland to Alabama, but it would have always the same general characteristics.

Thought Methods of No Value.—At first it was thought by the engineering investigators that none of the methods of classification so far developed would be of any service to the engineer, and that some form of granulometric classification would be much simpler and more satisfactory to the engineer as being comparable to his mechanical analysis of sand and stone. Therefore, until the beginning of 1926, the mechanical analysis of soils was stressed in the soils laboratory. During the fall of 1926, Dr. Charles Terzaghi, of the Massachusetts Institute of Technology, suggested for preliminary classification, that the Atterberg's liquid and plastic limits be used with the shrinkage limits and possibly the moisture equivalent and volumetric change tests of the U. S. Bureau of Public Roads. He further suggested that a final classification be based upon detailed tests that would give the modulii of compression and expansion and the coefficient of permeability of the soil.

The latest decision of those engaged in soil research for highway purposes

is to adopt the classification of the U. S. Bureau of Soils in order to avail themselves of all the good work done by the Bureau of Soils and to use their soil analyses, soil maps and all other available data. For engineering purposes the preliminary and final methods suggested by Mr. Terzaghi will be adopted unless proven unsatisfactory after a thorough study of the results so obtained by the three laboratories now engaged in sub-soil research, namely, the U. S. Bureau of Public Roads' Soil Laboratory and the two soil laboratories at the Massachusetts Institute of Technology and at the Ohio State University. The outlook now is that some very positive results will be obtained toward the definite classification of good and bad road sub-grade soils within the present year.

What Soil Characteristics Create the Trouble?—The second step in the research is to find what are the characteristics of the soils that cause the damage. Is it the swelling and shrinkage of the soil that constitutes the trouble, or is it the water absorption or the water holding capacity of the soil that makes the soil so plastic that it cannot support the loaded pavement, or, is it the climatic and temperature conditions that bring the excess water to the under side of the pavement and thus provide the free water which makes the soil so plastic that it has little or no bearing value? How does the excess water reach the soil beneath a water tight pavement? Does it penetrate by lateral seepage, by capillarity, or by rising vapors trapped beneath the pavement and later condensed by chilling temperatures? Or is the trouble just plain lack of engineering attention to proper drainage? The writer has found many a damaged road due to the later blunder.

The Search for Curative Measures.—The third problem before the investigators was to determine the most satisfactory and economical treatment for bad sub-grade soils. This search may be directed along several lines such as the direct treatment of the sub-soil by chemical applications — solutions of modifying chemicals, limes, oils and the like—or by admixtures with the soils of hydrated lime, portland cement, sands and other granular substances; the lowering of the water table by direct drainage; the separation of the sub-grade and water table by greater fills or less cuts; the interposition of granular sub-bases, which cut off capillary moisture, provide air circulation and consequent evaporation, provide for the drainage of condensed or seepage water from beneath the pavement, and finally, offer additional bearing material to distribute the load over a larger sub-soil surface, thus preventing overload upon the softened soil; or, finally, the pavement may be reinforced so as to reduce its deflection and thus strengthen it to withstand destruction over poorly supporting soils.

Part of this work of investigation may be done in the laboratory while part of it must be done in the field. Whatever is discovered must finally be put to a practical test in the field in order to prove its fitness to live as a workable improvement upon the present highly developed construction methods.

Difficulties Encountered.—The investigators have met many difficulties. Allusion has been made to those difficulties in the line of classification. The classification should be simply and easily determined. It should be definite, in that it should always classify a soil as good, bad or indifferent. Thus far, no single test, nor any group of simple tests, has positively separated individual good, bad and doubtful soils. In general, two or three of the tests have separated soils into groups of good, bad and doubtful soils, but in those groups usually lie one or more stragglers, that by the test of road conditions or the testimony of another one of the tests, should be classified in another group. In other words, the tests so far used do not completely correlate the soils with the road conditions, nor do they agree among themselves upon the character of the soil tested.

Another unsolved difficulty is to get a laboratory test that will truthfully represent a given field action. The soil in the field test is quite different than the same sample removed to the laboratory. The soil beneath the pavement slab is almost as greatly changed in character from the same kind of soil forty feet away in the field, as is the laboratory sample changed from the field soil. When the sub-grade is put into shape and rolled, or is compacted by the trucks hauling the paving material over it, it is entirely changed from its original character, such as the same soil holds in the adjoining field.

Soil Studies.—When the soil is brought into the laboratory, it must be dried, and the coarse material removed from it, in order to make any checkable laboratory tests. How does this coarse material affect the action of the soil in the field? The structure, the physical composition, the porosity, the layers, the columnar or amorphus condition in its natural bed; all the drainage channels formed by shrinkage cracks, worm holes, root channels, percolating and solution channels, the increased porosity due to freezing and thawing are all changed when the soil comes into the laboratory. What effect does oven drying have over air drying? How can clay soils be pulverized without breaking down partially disintegrated particles? How fine should the soil be pulverized in order to get the most uniform results in laboratory tests? Scores of other questions arise to the investigator's mind. A chemical may be added or admixture made in the laboratory and certain results secured, but here the operator has perfect control over temperature, moisture, method of mixing, over conditions of seasoning, or developing, and therefore fairly controls the results. How will it work in the field, in the rain, under the sun, after freezing, under the pounding of traffic, or with a clay soil so tough and sticky that it will not be broken up by the plow, harrow, pick or disc?

What Methods Are Practicable?—Is this or that method practicable? Take for instance the admixture of cement or hydrated lime with the sub-grade soil for hard pavements. The contractor has his contract to build a certain road with brick or concrete and must finish it on a given date or pay a penalty therefor. Heavy clay soil is encountered and the contract calls for an 8 or 10 per cent admixture of hydrated lime with 6 in. of the sub-grade soil. At this junction a wet season of 6 or 8 weeks arrives. There is absolutely no way in which a reasonable mixture of the adulterant with the clay soil can be made under such conditions. What can the contractor do? What will the highway department permit? What results will be obtained if half way methods are adopted? Such admixtures may be made with some semblance of success upon earth roads where time and conditions may be chosen to suit the work without serious inconvenience. but for important highways and hard surfaced roads such treatments are impracticable.

Mechanical analysis of a sand or a gravel is easily made, but when a soil is to be analyzed it must be handled very differently. The clay particles must first be washed out of the soil mixture, then the residue dried, and sifted into the various grades of sand and silt. Afterwards the clay is determined by evaporating the water, or a portion may be centrifuged in order to separate the clay into the coarser and the ultra fine particles.

The Work Done.—In the mechanical analysis the standards of the U. S. Bureau of Soils have been used. This standard makes 1 m.m. diameter the division line between gravel and sand. Sand grains range from 1 m.m. to .05 m.m. in diameter, silt from .05 to .005 m.m. in diameter and all particles below .005 m.m. are termed clay. The extremely fine particles not thrown down by centrifuging at 500 times gravity are called ultra or suspended clay. This ultra clay appears to be the material that causes swelling and shrinkage of the soil and undoubtedly is the material that prevents water from percolating through the soil and drain tile laid through such soil for drainage. It is probably the constituent of clay soils that makes them sticky when wet. If these assumptions are true, then any adulterant that will flocculate or collect these fine particles into granular masses will aid in drainage and also in making the soil less plastic. Hydrated lime has been found to do just that thing. Water moves more freely through soils that have been treated

with hydrated lime, therefore drainage has been secured. The resistance to flow under pressure has been greatly increased thus giving a much better bearing value to the soil. Other electrolytes will probably do the same thing. The question is how to apply such treatment to the soil in some practical way and not unduly interfere with the progress of construction.

The supporting power of soils was studied by Mr. A. T. Goldbeck[1] and it was discovered that for a given unit load applied to a soil over various areas, the depth of penetration varied directly proportional to the square foot of the area loaded. That for a unit load that would produce a penetration of 0.10 in. over an area of 9 sq. ft., the following equation would give the penetration for any other area with an equal unit load:

$$y=900x^2$$

Where y=area in square feet and x=penetration in inches.

This would indicate that the smaller the area, the less would be the penetration for a given unit load. Or for an area of 1 sq. ft. the penetration would be 1/30 in. for the same unit load as assumed for the 9 sq. ft. area above.

Most Soils Furnish Good Support.—As previously stated most soils encountered in road building furnish excellent support for the pavements when not containing too much water. The heaving due to swelling of the soil, the expansion due to freezing, the plastic or flow condition of the soil are all due to excess water in the soil. The soil investigation, therefore, has been to determine where the danger point is reached, how the water enters the soil and what treatment is best suited to stabilize the sub-grade soil. The various tests to determine these features will be considered here together with the results thus far obtained.

Water is contained in the soil in three conditions, namely: free, capillary and vapor forms. The free water can be removed rather easily by porous subbases connected to open ditches or to sub-drains, by French drains and by longitudinal tile lines along either side of the road.

Let a further word of warning and of emphasis upon this phase of drainage be given at this point. Perfect surface and sub-drainage of free water are only secured at the price of eternal vigilance. Attention is necessary to the permeability of the soil and to whether the water can actually percolate through the soil to the rain tile. French drains and porous bases must be so designed that the free water can be carried away to free outlets. Provision must be made to prevent melting snow and flood water from ready access to the sub-grade. Ditches must be kept clean, tile be kept from clogging with inflowing soil, outlets always maintained free, ditches freed from melting snow and slush in the spring by some form of dragging. Cracks in the pavement must be sealed, ruts filled and earth cracks at the edge of the pavement sealed.

All springs encountered anywhere in the right-of-way should be drained away from the road. Wherever the sub-grade cuts across the junction plane between a pervious and a nonpervious stratum of soil, herring bone cross drains should be placed beneath the pavement to free the base from longitudinal moving seepage water. It is only by this strict attention to construction and maintenance details that the evils of free water may be practically eliminated. When this attention to detail is given, at least one-half, probably more than one-half, of the sub-base troubles will be removed. Yet with all this care the capillary moisture has not been greatly reduced.

Capillary Investigations. — Physics teaches that capillarity depends upon the surface tension of a liquid. Temperature and the viscosity of the liquid affects its amount. The height to which water will rise in capillary tubes is inversely proportional to their internal diameter. Impurities in the liquid also affect the capillary action.

It is thus seen that the capillary action of water in soils is very largely affected by the fineness of the soil particles. It is also affected rather markedly by the temperature of the water and soil. Alkalies and other soluble impurities will also affect the rate and height to which water will rise in soil. The amount of capillary moisture held in the soil is dependent upon the shape and size of the soil grain.

The range of capillary moisture found in the Ohio soils has been from 20 to 95 per cent of the dry weight of the soil.

Mr. I. B. Mullis states in the Proceedings of the Fifth Annual Meeting of the Highway Research Board that tests have proven that "The percentage of capillary moisture held in a uniformly graded and compacted soil column free from evaporation decreases as the height above the water table is increased."

The percentage of moisture held under capillary tension diminishes as the temperature increases. Mr. Mullis shows capillary moistures of 33 to 37 per cent in several soils at heights ranging from 24 to 29 ft. above the water table. On these same soils he computed the possible capillary rise in feet to range from 50 to 231 ft.

McLaughlin Investigation.—Mr. W. W. McLaughlin, in the May, 1921, issue of Public Roads, gives some very interesting data upon observed capillarity in western soils. He notes that capillary rise is very rapid for the first 24 to 48 hours and that it gradually slows up as time increases. With a lava ash soil it rose 16¼ in. in 24 hours but took 30 days to rise 54.5 in. This same soil lifted 1.8 in. of water 5 ft. from the water table in one year, and 3.3 in. of water 4 ft. in the same period. Mr. McLaughlin draws the conclusion that it is useless to attempt to keep high capillary moisture from beneath the road where the side ditches or the subdrainage is near the sub-grade elevation.

Table I, following, shows the heights in centimeters to which capillary water was raised in six Ohio soils.

Table I, Capillarity of Soils

Soil Numbers	182	74	126	34	21y	67
Percentage of Clay in the Soil	22.2	39.3	45.5	59.9	77.1	96.1
Percentage of Silt in the soil	39.0	31.3	37.0	33.6	11.1	3.0
Percentage of Capillary Moisture	29.6	30.2	27.2	34.2	24.0	39.4
Capillary Height in Centimeters attained in 15 days	120	67	41	60	36	23

The extreme difference between soils was shown in this test when it took only 15 days to raise the water through 120 centimeters of soil No. 182, while it took 103 days to raise it 80 centimeters through a column of soil No. 126.

Free Water Due to Two Actions.—It is probable that the free water found beneath pavements in the early spring is due to two actions. First, the condensations of vapors which rise through the soil beneath the road slab and are condensed against the slab when it is chilled at night or by any sudden drop in temperature. Second, by the capillary water which rises in greater quantity due to the effect which cold has in creating a greater surface tension. This greater amount of capillary water is frozen and held there, in fact, the ice spicules are even forced out by the increased capillary power behind them, until the water coming in by the vapor route there is a considerable mass of free ice formed beneath the pavement. When the thaw occurs there is an excess of water to form a plastic mass of the sub-grade soil.

A coarse sandy soil takes care of these conditions, first, because capillarity is very much less; second, because drainage is very much better and any free water, no matter by what route it arrived beneath the pavement, is promptly drained away.

Mr. Mullis found in his sub-grade tests at the Arlington Farm, according to Public Roads of October, 1921, that the use of 3 and 6 in. of gravel upon the sub-grade beneath the road slab prevented capillary action for that depth below the slab, permitted side drainage, and therefore the slabs so treated had the least free water beneath them of any of the tests made.

A comparison made of the soils tested in the Ohio State Laboratory with the conditions of the roads, comparing also the moisture equivalent, the volumetric change, the clay content and the lower liquid limit of Atterberg with the capillary moisture, all seem to indicate that when the capillary moisture of any soil exceeds 27 to 28 per cent, that soil should be classed as undesirable for sub-grade purposes.

Volumetric Change.—The U. S.

Bureau of Public Roads has established as a standard for the determination of the shrinkage value for a soil, that the soil shall be saturated to the capillary moisture, then dried, and the percentage of shrinkage thus secured. This shrinkage, termed volumetric change, varies from zero to 40 per cent of the original volume of the wet soil for the Ohio soils.

A. C. Rose, in Public Roads, August, 1924, describes a method of determining lineal shrinkage which represents about 36 to 38 per cent of the volumetric change. In this article he makes the following findings:

"A moisture equivalent percentage of 20 seems to be critical in respect to the bearing power of a soil. When wetted beyond this value the bearing value falls rapidly" . . . .

"That the lineal shrinkage percentage test detects poor sub-grade soils which pass a favorable moisture equivalent test or vice versa."

"That when the lineal shrinkage percentage is greater than 5 per cent, it seems that precautions should be taken to insure a road surface against failure due to sub-grade soil movement."

The work at the Ohio State Engineering Experiment Station upon some 275 soils indicates that there are a few undesirable soils having a lineal shrinkage value less than 5 per cent. There are also several soils with higher shrinkage values that have not yet caused serious trouble to the roads—but which the moisture equivalent test, the clay content and Atterberg's limits all show them to be undesirable.

Moisture Equivalent and Water Content.—The moisture equivalent of a soil is that percentage of water retained by a saturated sample after being centrifuged for one hour at a centrifugal force, 1,000 times gravity.

A. C. Rose, in Public Roads, August, 1924, sets a moisture equivalent limit of 20 per cent. He claims from his observations that any soil having a greater moisture equivalent limit is suspicious.

Mr. Rose, in the same publication, September, 1925, stated that of 103 samples of soil tested only seven showed a field moisture content in excess of their respective moisture equivalents, and that only one of these had a greater excess than 2½ per cent. He suggests, therefore, the possibility of the control of the water content of the soil so that the moisture equivalent will not be exceeded. However, he states these values were only summer observations and would not probably hold in winter or in rainy conditions.

Must Build Roads for All Year.—The highway engineer must build his roads for year round conditions and cannot afford to base his designs upon halfway assumptions. Observations upon Ohio soils, made at the Ohio State Laboratory, show 16 cases out of 45 soil stations where the average moisture content at 12 in. depth ran over the moisture equivalent from zero to 13.4 per cent, averaging 3.2 per cent excess for the 16 stations. Two years' observations upon 27 soil stations show that for the months of January, March, May and September, selected as alternate months, 16 to 22 stations, each month, out of the 27 stations gave moisture contents in excess of their respective moisture equivalents; of these 9 to 21 stations, each month, were more than 4.0 per cent greater and from 2 to 15 stations, each month, gave more than 10 per cent increase of water content over their respective moisture equivalents. Of 16 stations observed in July only two stations showed greater water content than their respective moisture equivalent, but were 7.2 and 10.5 per cent greater, respectively. In some cases the water content at depth of 18 and 24 in. was 15 to 20 per cent greater than the moisture equivalent. Therefore, for Ohio soils it would be impossible to support Mr. Rose's observations.

From the Bates road tests it appears that the water content of the sub-base soil at time of construction may affect the water content therein for one or two years; wetted sub-grades seem to resist further advances of moisture content for long periods. This conclusion would corroborate Mr. Rose's suggestion that there is a possibility of moisture control in sub-grades.

Dr. Terzaghi, in Public Roads of October, 1926, says:

"That for plastic soils, the moisture equivalent has nothing to do with the drainage properties of the soil. It merely tells about the compression produced by a certain pressure."

"For soils intermediate between plastic and friable soils the moisture equivalent has no definite meaning at all."

With reference to the moisture content of soils the conclusions of the tests at the Ohio State Laboratory are:

1. The surface of the soils tested change their moisture quickly from 2 per cent to 124 per cent of their dry weight due to rain, snow, thawing and dry weather.

2. That sub-soils below 6 in. in depth change comparatively slowly in water content and over much narrower margins. The general averages range from 13 or 14 per cent to 22 or 23 per cent water content, except in open fields or beneath concrete slabs, where it may run to 26 or 28 per cent.

3. That for the dry portion of the summer or fall the water content of the sub-soil may run from 60 per cent to 65 per cent of the water content during the winter and spring.

4. That due to some undetermined factor, possibly exposure, sub-drainage, soil composition or a combination of all, certain soils show nearly double the moisture content at all times than do other soils.

5. That wet and dry years may make 30 per cent to 50 per cent difference in the amount of water which any given soil may hold.

6. That fluctuations occur in the water content of sub-grade soils which it is impossible, from the present data, to trace directly to rainfall, evaporation, or other surface weather conditions.

Pavement Displacement.—A series of level observations were made during 1925 and 1926 upon twenty or more stations located at different points on the Ohio State road system, in order to determine what effect, if any, the swelling and the freezing of the soil beneath the pavement would have upon pavement displacement. The deepest frost encountered during the coldest part of the two years was 14 in. The stations being widely separated over the state prevented the taking of as many observations as should have been taken. Consequently, the information regarding the beginning of the pavement displacement and its rate of rise is incomplete. However, the readings taken in February were so timed as to catch the maximum rise due to freezing, and it is believed the same is true of the rise in August, 1926, caused by the excessive rains of that summer.

The Conclusions

1. The amount of displacement ranges from .025 to .265 ft., averaging about .063 ft. This for the two seasons of 1925 and 1926 in Ohio which were rather mild seasons.
2. The displacement is due both to moisture and freezing. There is not sufficient data to evaluate the amount due to each cause. In three cases the maximum elevation occurred in August, indicating that moisture and soil swelling was the cause. The extreme elevation usually occurred in February, suggesting that the major factor for heaving is frost.
3. No relationship could be established between the rise and fall of the pavement and the soil characteristics and mechanical analysis. Except that the increase and decrease in displacement of pavements over different soils varies somewhat according to the capillary moisture of those soils.
4. The displacement of the pavement begins upward in the late fall and early winter, usually reaches a maximum in January or February and falls abruptly with the spring thaw. The pavement remains nearly uniform during the late spring, summer and early fall, changing only slightly as the moisture in the soil varies during these months.
5. The cycle is usually complete, the pavement rising from a given elevation and returning to the exact same elevation. This occurs many times without evidence of injury to the pavement, but undoubtedly uneven settlement does occur and eventually cracks must be found.

Glinka quotes Ismailski in the latter's "Soil Mixture and Ground Water" as follows:

"That during the six years period (of observations) the average annual moisture content had varied considerably. These variations were not influenced by the amount of the average annual rainfall but were determined mainly by its character and by the season in which the greater amount of it fell. The spring and autumn precipitations were of greatest importance while the summer rainfall exercised but slight influence. The soil is driest therefore at the end of summer and the beginning of autumn."

The observations made at the Ohio State Laboratory coincide with those made by Ismailski.

Percolation.—The percolation factor may be expressed as the cubic centimeters of water percolating through a unit area of soil of a given depth in one hour. The Ohio State Laboratory has adopted a unit area of one square centimeter, and a depth of 20 centimeters, and a depth of water upon the soil of two centimeters. The unit of percolation is then cubic centimeters per square centimeter per hour. In

farm drainage the co-efficient of drainage is usually one-quarter or one-half inch per 24 hours. One-half inch of drainage in 24 hours is equal to 0.053 cubic centimeters per square centimeter per hour.

The percolation test of the laboratory must be quite different than the actual percolation in undisturbed field soil—but it more nearly simulates what would occur along the road where the soil has been plowed and puddled and compacted so as to render it quite unlike the undisturbed field soil.

This rate expressed for 10 in. of soil would be much reduced if it were for 2 or 3 ft. of soil, the usual depth used over tile drains.

The value of this test is twofold. First of all, it serves to indicate that in certain dense soils tile drainage would be a waste of money, for no surface nor seepage water could reach the drain except by special catchbasin inlets or a porous backfilling. Second, that water cannot escape from beneath the road slab laid upon such soil unless special provision is made for its drainage. It is further a measure of the density of the soil indicating high capillarity and all the other undesirable features of the soil.

The range of values for percolation is great, running from zero for many fat clay soils to several cubic centimeters for very coarse sandy soils.

Slaking Value.—It is believed that the slaking value test will give valuable information regarding the stability or non-stability of the road shoulders, the ditch banks and the embankments through cuts. In the case of construction upon old location much can be told from the conditions as found, but in relocation and new work this test should be invaluable. Tentative values, only, are assigned at present until a more desirable correlation has been made between the laboratory tests and the actual behavior in the field. The suggested limits are as follows:

Quick slaking soils,—dangerous,—below 20	
Questionable soils	20 to 30
Soils fairly stable	30 to 50
Excellent soils	50 up

A practical and simple field test can be devised to give the desired information.

Atterberg's Limits. — Experimental work has been going on for some time to determine whether more consistent classification can be obtained by means of the limits suggested by the Swedish investigator Atterberg. Thus far the soil characteristics developed by the U. S. Bureau of Soils and the Bureau of Public Roads appear to classify the soils as surely as do the Atterberg limits. Atterberg's lower liquid limit is the only one of the three that agrees closely with the U. S. standards. The Atterberg tests are more easily made and would be quite desirable if they gave as definite knowledge of soil action as the other tests.

Freezing Data.—Mr. A. M. Wintermyer writing in Public Roads, February, 1925, gives data proving that seldom does all the water in a soil freeze. That such freezing as occurs seldom begins above -1.5°C and that much of the water held by capillary tension is not frozen until temperatures between -4.0° to -78°C are reached. It appears from this series of tests that the finer grained soils hold the water under such tension that it freezes with greater difficulty. Probably the chemical composition, the organic content, colloidal material and the soluble salts all affect the ease with which freezing occurs and the total amount of water frozen.

The amount of water frozen varies from zero to 100 per cent. In the case of soils from the alkali regions no water was frozen, while for coarse quartz sand 100 per cent was frozen. The tests showed a marked decrease in the contained water frozen as the clay content of the soils increased.

Stephen Taber in the Engineering News Record, Feb. 7, 1918, describes some experiments in which weights placed upon sand were not raised when the sand was frozen. Similar weights placed upon clay soil were lifted by pure ice which formed upon the clay beneath the weight. The ice formed in columns as "Needle ice." The conclusion reached was that the raising of the weight was due to the growth of the ice, which was forced up by the capillary force beneath it in the dense clay soil. Similar results were produced from the crystallization of salts from super-saturated solutions.

Georgia Experiences.—Prof. C. M. Strahan, of the University of Georgia, has carried on extensive investigations of soils with reference to their characteristics and actions in the construction of sand-clay and clay-sand roads. Some of his conclusions are:

The functioning of these road soils seems to be as follows:

1. The large amount of sand, particularly the coarser grades, furnish the hardness and resistance to wear.

2. In graded mixtures, the coarse sand embedded in the fine sediments of silt and clay develops a strong mechanical bond.

3. The adhesive value of the clay provides the binder which holds the sand in place during dry weather.

4. In wet weather the clay binder softens, but the mechanical bond of the coarse sand remains to support the traffic.

5. The density of the entire mixture prevents ready penetration of water. The expansion of the clay tends to close the capillary openings and protect the interior of the slab. Excess clay, however, by its too great expansion dislocates the interlocking mechanical bond of the sand and permits the traffic to cut into the slab layer by layer.

6. The capillary structure of the consolidated road soils, unlike that of many fine silty soils, prevents self-saturating action from below when the adjoining soils are filled with water.

He says: "It is seen that (1) hard silica gravel is a source of great strength to road soils; (2) sand above No. 60 sieve from 40 to 60 per cent in amount is present in the best grades; (3) silt exceeding 20 per cent is regarded as a weakness; (4) clay exceeding 25 per cent gives a soft surface easily cutting into mud. The best samples show a clay content between 10 and 15 per cent."

Specification Limits.—Prof. Strahan gives as specification limits for Class A and B roads the following:

	Class A	Class B
Clay	9 to 18 per cent	15 to 25 per cent
Silt	5 to 15 per cent	10 to 20 per cent
Sand above No. 60 sieve	45 to 60 per cent	30 to 40 per cent
Total sand	65 to 80 per cent	60 to 80 per cent

As these conclusions were reached after several years of careful observations upon the action of a great many miles of Georgia roads they bear much weight upon what to consider as the composition of good road soils, whether they are for sand-clay surfaces or for hard pavement sub-bases.

Sub-Base Treatments.—Mr. C. L. McKesson, Proceedings of the 5th Annual Meeting of the Highway Research Board in his report upon "Sub-grade Treatment Experiments at Rio Vista, California," makes the following conclusions:

1. That the soil adulteration with cement or lime compounds is not an efficient or economical method of securing stability in heavy soils.

2. That the suitability for soil for sub-grade purposes, or of the merits of various methods of soil treatments, can be determined by relatively simple laboratory tests and that expensive field tests can in some cases, at least, be avoided by first resorting to a properly conducted laboratory investigation.

3. That a sand or gravel layer is an efficient and economical method of minimizing damage to pavement resulting from swelling or shrinkage of the subsoil.

The conclusions reached in the Pittsburg, California, road test were as follows:

1. Adobe soil, pulverized and compacted in 6 in. layers for 3 ft. in depth made a reliable foundation soil for these tests.

2. This adobe soil foundation was not injured by water which filled the side ditches to the level of the base of the pavement for three months.

3. A 12 in. rock base upon this soil, constructed of two 6 in. layers, the bottom course composed of stone from 1¼ to 1½ in. in diameter and the top course of stone ¼ to 1¼ in. in diameter, these courses thoroughly compacted and covered with 1½ in. of earth, was less efficient than the earth base.

Two years' experience with sub-base treatments upon a road in Ohio show that various porous layers such as sand, gravel and slag reduced the average

ratio of cracks to lineal foot of pavement from 1.20 ft. of crack upon the natural soil, which was a heavy fat clay, to from 0.45 to 0.74 ft. of crack upon the porous bases. The cement soil admixture was practically the same as the natural soil base.

Ratio of Cracks.—The ratio of cracks occurring during the second year was even more favorable to the porous bases. The conclusions reached are:

1. The cement-clay admixture appeared during construction and showed in its after results to be little if any different than the natural soil base.

2. The porous bases show thus far much less cracking than do the natural soil and the admixture of cement and soil bases.

3. It is unsafe at this time to differentiate between the safety of the 2, 4 or 6 in. porous bases, or to draw conclusions as to their sufficiency to save the road maintenance an equivalent of their first cost.

Mr. R. W. Crum, of the Iowa State Highway Commission, writing in Public Roads, August, 1925, describes the difficulties encountered in trying to prevent hair cracks in concrete pavements laid upon the loess soils of northwestern Iowa. A mechanical analysis showed it to be about two-thirds silt and one-third clay. It had a lineal shrinkage of only 2.3 per cent but a high capillary moisture of 43.7 per cent. Laboratory tests showed that concrete slabs laid upon this soil when dry or slightly damp developed many cracks within three hours after being laid, but if laid upon the saturated soil they did not crack. Tarred paper between the sub-base and concrete also prevented the cracking. Dry mixtures of concrete showed less tendency to crack.

On their later contracts the Highway Commission required the use of tarred paper upon all loess soil subbases and have practically eliminated the cracks.

Mr. Mullis' Conclusions.—Mr. I. B. Mullis drew the following conclusions from his tests at the Arlington Farm on the High Capillary Potential:

1. Keep the water table as low as permissible.

2. Promote aeration and draining by use of granular materials having filtering qualities.

3. Cut back trees where necessary so as to give fullest exposure of the roadway to the sun and wind.

Mr. G. H. Henderson, Chief Engineer, Rhode Island State Board of Public Roads, in a recent paper before the Highway Research Council, says in speaking of that state's experience with sub-soil beneath their very successful bituminous macadam roads:

"It is our practice to replace poor sub-soil with a uniform layer of gravel or stone foundation, the depth varying with the degree of tightness of the soil. The only rule that we have for determining the proper depth of foundation is the "rule of experience." We have seldom found a case of bad sub-soil that a uniform layer of 12 in. of coarse, permeable gravel would not take care of provided it is tapped out through the shoulders and properly drained.

"Through particularly bad, mucky soil we sometimes have laid a blanket course of sand or fine gravel, usually 4 to 6 in. in depth, over which we construct our standard stone fill. The object of the blanket course being to hold the muck down and prevent its rising and filling the interstices of the foundation above."

Laboratory Test Information.—The laboratory tests are giving the soil investigator a wealth of information regarding the peculiarities and characteristics of the various soils, and as Mr. McKesson says, much may be learned in the laboratory as to how certain treatments will act, or at least as to whether there appears to be sufficient promise to make it worth while testing out in actual field practice, but after all, we are very dependent upon the great mass of information which may be gathered from the actual results in the field for our final conclusions as to the most practical and economical methods of sub-soil treatment.

What the States Are Doing.—Briefly, what the various states are doing in sub-soil investigation or what use of present soil knowledge is being made in practice will here be described.

Georgia. The work done in Georgia has already been described.

North Carolina attempted to classify soils back in 1921. Not much of consequence has been done since that time until recently the University of North Carolina has begun an investigation of the capillarity of soils.

Pennsylvania is co-operating with the U. S. Bureau of Public Roads in a series of investigations upon the admixture of sand and cinders with the soil by harrowing, also by the use of blankets of cinders and sand used on top of the soil. Tests are also being carried on upon moisture equivalent, the bearing power of soils and other research problems.

Ohio is also co-operating with the U. S. Bureau in a sub-soil research, sub-grade treatments of the soil, a moisture content survey of the soil and in measurements upon pavement displacements by frost and soil movements.

Michigan has been studying the subsoil question for about a year and a half. An extensive survey is under way co-ordinating road conditions with an analysis of the soils along the roads. The Highway Department has completed and published the results of a very complete survey of the settlement of fills on peat marshes. Sub-soil treatments with sand and gravel sub-bases have been tried. One project in Monroe County has stretches of half a mile without a crack in the 100 ft. slabs into which the pavement is divided. The road has been down through two winters.

Illinois began soil studies in 1923, when moisture content of the sub-soil was observed during the Bates road test. The control of soil stability by admixtures was also investigated at that time. Apparently lime and cement admixtures were unsatisfactory—but sand, silt and clay added in certain proportions seemed to stabilize the soils. No cost comparisons were made.

Iowa has been working several years on the effect which sub-soil characteristics have upon concrete roads. The soil is being analyzed and a record of road conditions made. The research has not progressed sufficiently yet to secure enough data upon which to base a report. Last year Prof Q. C. Ayres of Iowa State College made a study of the loess soils of northeastern Iowa and reported upon them. He suggested the removal of the soil in the bad spots and its replacement with good top soil.

Colorado is co-operating with the U. S. Bureau of Public Roads in a survey of sub-grade soils, begun in January, 1925. They are co-ordinating soil analyses with the conditions of their concrete roads. For new construction the soils are tested along the proposed line and where lineal shrinkage greater than 5 per cent is indicated the subbase soil is treated to a sand mixture. Usually 4 in. of sand is mixed with the sub-base.

Minnesota is making the usual tests upon the sub-soils of all its new roads. Samples are being taken at quarter-mile intervals, field observations made and maintenance costs kept on about 200 miles of its highway system. Marl is used on sandy soil and oil upon heavy clay soils before the road is graveled.

California has given sub-soils considerable attention since the Pittsburg tests in 1921. Field and laboratory tests are made upon all its work. Pavements are insulated from adverse clay by a 6 in. sand or gravel course. Sulphate soils are coated with a heavy coat of asphaltic oil, upon which sand is sprinkled to prevent tracking. So far the results seem to justify the precautions taken. In alkali soils the samples are taken from the top 2 or 3 in. of the soil where the greatest concentration of alkali is found. The California Highway Commission uses but two soil tests upon which to base its decisions—shrinkage and moisture equivalent—using Mr. A. C. Rose's standards.

Washington state varies the design of its pavements to fit soil conditions.

Other states may be, and some of them undoubtedly are, doing something along sub-soil investigation and control, but the information is not at hand.

Summary.—In attempting a brief summary of the progress made both in the laboratory research upon sub-soils, and the attendant progress made in the field by the construction departments in the treatment of sub-grade soils, only the high spots will be mentioned.

1. There has been a distinct advance in our ideas about soil classification. The present Bureau of Soils classification supplemented by that of the Bureau of Public Roads is far ahead of any thing heretofore proposed.

2. McKesson's suggestion that much useless expense for field tests might be saved by first trying out the plan in a small way in the laboratory, is well worth while.

3. It is very encouraging to know that six or eight states are already striving to put into practice the knowledge thus far gained.

4. The corroborative experience from several sources that porous sub-bases are actually reducing the evil effects of poor sub-grade soils. As proof, note that the crack ratio of concrete over porous bases is less than half that on heavy clay soils.

5. The equally corroborated experience that lime and cement admixtures with sub-soils, for hard surfaced roads, are both inadequate and impracticable.

6. Prof. Strahan's specifications for good top soil, for Class A roads, that clay should not exceed 18 per cent, silt should not exceed 15 per cent and that total sand should be between 65 and 80 per cent in order to make a stable, water resisting material.

7. The discovery that for a given unit load, the depth of penetration varies directly proportional to the square root of the area loaded. This is valuable information for the designing engineer.

8. The recognition that free water can be removed from the highway providing attention is paid to details and the fact that such attention sholl continue unabated throughout the period of maintenance.

9. The greater knowledge of the capillary movement of water in the soil. Its rapid rate of rise near the water table and the much slower rise as the distance from the source of supply increases. The decrease in the amount of capillary water held in the soil as the distance from the source increases. The relation existing between capillary water and clay content of a soil suggests that soils with higher capillary moisture than 28 per cent should be considered as under suspicion.

10. The fact that pavements which are displaced by frost and swelling soil, go through the cycle of rise and fall many times without cracking and that they will return to the initial position under similar conditions.

11. Rose's limits for shrinkage at 5 per cent and moisture equivalent at 20 per cent seems to be working out satisfactorily in practice where they have been used.

12. The value of tar paper as a water proofing agent when placed upon sub-bases where the soil is of such character as to draw the water of hydration out of the fresh concrete, thereby causing cracks.

13. The availability of the percolation factor to indicate what soils can or cannot be drained by tile or stone sub-drains.

14. The possibility of developing a slaking test that will guide the engineer in the care and maintenance of the road shoulders, ditch banks and cut banks.

Some Important Further Needs.—1. A more intelligent investigation of the dangers in making cuts for the purpose of balancing cut and fill. The danger is in cutting through good soil and establishing the sub-grade on the worst soil to be found in that locality.

2. More care in location throughout bad soil areas. Such, for instance, as the location of the road where a cut has to be made near the foot of a talus slope where landslides will pretty surely happen when the existing stability has been upset.

3. Better record of sub-soil conditions, construction details, and maintenance required on a considerable mileage of paved roads through both good and bad soil areas in order to evaluate the actual costs of bad soils.

4. The need of having a trained soil engineer attached to every State Highway Department to study soil conditions throughout the state and advise upon every road constructed.

5. The evolving of a simple bearing value test for sub-grade soils.

6. The discovery of some simple method of controlling the moisture content of heavy clay soils for at least 2 ft. beneath the pavement.

Improvements in Insley Excavator

The Insley Manufacturing Co., Indianapolis, Ind., has announced several improvements in its Type C excavator. The company is now prepared to furnish a machine with a completely enclosed steel cab equipped with swinging windows and sliding steel panels which permits ample light for the operator and complete accessibility to every working part and at the same time effects the maximum protection to the machinery.

Another improvement incorporated in this machine is the adoption of the one shot lubricating system to crawler rollers. In the past the moving of an excavator under its own power over a long distance has presented something of a problem in keeping the crawler bearings properly lubricated, sometimes necessitating the use of an alemite gun three or four times during a trip of five miles. With the one shot system it is never necessary for the operator to leave his seat to oil these rollers, as this system is controlled by a cylinder and plunger mounted in front of the control levers, within easy reach of the operator's seat.

The Insley Co. also is announcing an addition to its line in the form of a backfiller attachment with a 30-40 telescopic boom, which boom can be extended to a length of 50 ft. by the addition of a 10-ft. intermediate section.

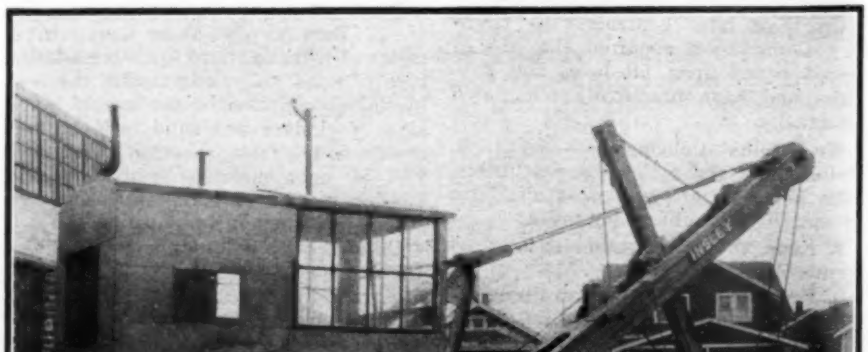
Mechanical Installation of Concrete Road Joints

Concrete roads in which both transverse and longitudinal joints are being installed mechanically is one of the latest developments in connection with modern road building.

The Flexible Road Joint Machine Co., Warren, O., which manufactures these machines claim that by the use of them, both longitudinal and transverse joints are built in the concrete roads by mechanical process. It is claimed that a flexible concrete road can be built which will not fracture transversely or longitudinally. This system has been used by some of the leading highway departments and has been the subject of discussion by engineers for the past several years.

On the now famous demonstration road on the Lee Highway in Virginia which has been built by the Virginia State Highway Commission and the U. S. Bureau of Roads, both longitudinal and transverse joints were installed by the use of this machine. It is claimed that center longitudinal joints can be installed to perfect alignment and when these joints are filled with hot bituminous filler, produces a distinct and permanent traffic line.

It is claimed also that the transverse joints installed by this system will eliminate entirely transverse contraction cracks in the concrete and that by the use of this system in constructing both longitudinal and transverse joints, it is possible to construct what is deemed a flexible concrete road.



Insley Type C Excavator with Enclosed Steel Cab

State Versus Contractors' Control of Materials

A Contractors' View of State Purchase of Cement for Highway Construction Given in Paper Presented Jan. 12 at 24th Annual Convention of American Road Builders Association

By A. F. JOHNSON
Contractor, Minneapolis, Minn.

The control of material must necessitate the purchase of material. In general no state has entered into the purchase of material for construction purposes, excepting in highway construction, and so the writer will limit this discussion to material used in highway construction.

The advent of any state into purchasing of material is of recent date, commencing about 1921, and was brought on by the tremendous increase in demand for hard surfaced roads in 1920. This necessitated a big increase in material needed and the existing producers in many cases were not equipped to take care of this large demand for their product. An unusual shipping situation also developed in 1920 and the construction program was slowed down.

The two main reasons that induced some states to purchase material at that time were: 1. To insure sufficient supply of material. 2. To reduce the cost of such material. These same reasons are today the governing factors when a state considers the purchase of material, especially cement, for its highway work. Therefore, this paper will be devoted mainly to a study of these two factors. An argument has been advanced for states purchasing cement that they would then get a better quality of cement and be assured that the right amount of cement was used. With the inspection and supervision that all states have on road work, there can be no question of quality or quantity whoever furnishes it.

Purchases By the State.—To insure greater production and lower costs some states did help to finance aggregate producers. One state in order to increase its pavement mileage even went into the construction of roads itself, with disastrous results. To insure a supply of cement and save money, several states bought their cement direct and stored a certain portion for each contractor. One state furnished the cement, rock and sand on its work during such a time of material shortage as we had in 1920 and found that it was not helping the situation by its control of material, but was thereby causing friction between its engineering department and the contractor, and was confronted with claims filed by the contractor for losses due to non-delivery. That state has gone out of the material business entirely. The writer questions very much that the result would have been any better, if the states had controlled the material during 1920; most likely it would have been worse.

There is at present and will be in the future a sufficient supply of material for road construction and we should not have another 1920. The price has been decreasing irrespective of who furnished the material. This sufficient supply of material has been brought about by the law of supply and demand and not as a result of any state purchasing material direct. Our road program has become stabilized and material requirements are known nearly a year ahead of time.

The writer feels certain that no state is at present contemplating purchasing or controlling aggregate. That contractors can purchase these just as cheap or cheaper than a state is a well conceded fact. This applies also to other material, such as steel, piling, lumber, etc. The cement is the largest single item of material used on road work, therefore, the question of the purchase and control of cement is what we are mostly concerned over.

Purchase for Bridges.—For state highway work, cement is used mainly in pavements and bridges. One state purchases the cement for bridges as well as pavement. Assuming that the state does save the cash discount and the dealer's differential, the writer feels that on work as small as most highway bridges are, requiring only small lots of cement at a time, that if the contractor could purchase his cement from a local dealer, that the value he would receive in using the dealer's storage shed and possibly the dealer doing his hauling, would more than compensate for any saving made by the state in purchasing this cement. The purchase of cement for pavement is therefore the main point of contention.

There are three parties concerned in the control of cement for highway work; the cement company, the state and the contractor. It is quite obvious that a cement company that can sell a large volume to the state at one sale will cut down its selling costs over selling that same amount to a number of different contractors. That cement company would also know at the beginning of the year, its quota of road cement and govern its output accordingly. The writer is inclined to feel however, that the small producers would be discriminated against, in that the state purchase would most likely be from the large producer, the price of course being the same.

By the state purchasing the cement, what competition there should be is entirely destroyed. In one nearby state, which did not purchase its own cement last year, there developed quite a cement war between dealers and even between producers and the price of cement was cut considerably. The writer doubts that this would have occurred if the state had purchased the cement and surely there would have been no reduction in the price of cement to the state.

Supply of Stocks.—The question of supply of stocks of cement by companies in general would be no different if the state purchased the cement in January, of if it was left to be purchased by the contractor later in the season. The cement industry is a well-organized business and they take notice of, and provide for the requirements of the state highway work, whether it is purchased at once or during the season. The contemplated program in any state will be known even before the state can purchase the cement required. That the state is assured of a better supply by storing cement on each job goes without question. This, however, is not done before a contract is let to a contractor and assuredly the contractor can store his own cement just as easily as he can store the state's cement. Furthermore, the state can insist that the contractor purchase at once and store whatever portion of the cement they deem fit.

Now, let us see what saving, if any, a state does make by purchasing its own cement. The states purchasing cement do so generally in January and February. During the last four years, there has been in general a fluctuation of 10 ct. a barrel in the price of cement, the low price occurring in the fall of the year and the advance taking place in January and extending until about October. Last year there was no change in the price of cement. States that have purchased their cement have done so generally in January or February and it is quite evident that they have been paying the high price. Furthermore, if these states were to buy their cement in the fall of the year for the next year's requirements, then no doubt the price of the cement would be advanced at that time rather than in January.

No Dealer's Differential.—When the state purchases cement it does not pay the dealer's differential of 10 ct. which some have considered a saving for the state. The writer questions very much that except in isolated cases, a contractor on paving work does pay any dealer even as much as 5 ct. per barrel

differential. In the writer's experience over the past three years and working in two states, 1 ct. per barrel would be a fair average of what he has paid and what other contractors to his knowledge have paid on this dealer's differential. There are, however, concessions made to contractors when they are in the market for the purchase of cement themselves, that the writer feels will overcome any saving in dealer's differential made by the state purchasing this cement direct. There are generally accommodations to be had from the local dealer and also when the contractor has the routing of the cement to make, he will generally get concessions from the local railroad companies on sidings, service, etc., by giving them the haul. He furthermore has a better control of his sack loss which in some cases has been large when the state has furnished the cement, in which case, the contractor has little if any recourse for adjustment of this loss.

All states, no doubt, would take their 10 ct. per barrel discount on their purchase of cement. A responsible contractor does the same, and if he is not able to take his cement discount he should not be in the business of highway construction. It is the writer's opinion that where the contractor furnishes his own cement that the contractor figures in his cost the net price of cement, that is, with the discount and cost of sacks taken off.

Financing the Purchase.—It is quite evident that whoever purchases the cement has to finance same and this must be of some cost to the state and also more clerical work and responsibility falls upon the state highway department when they handle the purchase of any material direct. With the addition of this cost to the state, the writer feels that there can be very little, if any, saving in the cost of the cement to the state by its own purchase.

If a state was to take two bids on a project at the same time, one where it purchased the cement and the other where the contractor furnished the cement, either bid from a responsible contractor should bring about the same cost to the state. This last year, one state took bids on one job with the state furnishing cement and later on took bids on the same job with the contractors furnishing the cement, with the result that they awarded the job, with the contractor furnishing the cement at a saving of $1,500.

There is, however, a saving in the amount of the bond premium by omitting the cement from the general contract. This saving will amount to about $100 per mile. By reducing the amount of money involved the state is, however, inviting a lower standard of qualification, which must mean more irresponsible contractors. There surely are plenty of competitors in highway construction without lowering the skill, responsibility and general standing of such competitors. There are, no doubt, enough responsible contractors in the field today to pave twice the mileage contemplated for this year. Furthermore, if we should have a shortage of material like we had in 1920, the state will lay itself open to claims for loss of time, etc., due to non-delivery of any material that the state is furnishing.

Effect on Bids.—Let us see how the question of cement purchase affects the contractor's bid in figuring on such work. If the cement is furnished by himself, he will add to his cost an additional premium of about $100 per mile for the contract bond. He will also have to use additional finances to carry through the purchase of cement. This is no burden to a responsible contractor, but as a business proposition the extra money involved should be figured with interest at 5 per cent. This rate of interest to take care of handling the cost of sacks, discount and the 15 per cent carrying charge on the work done would amount to about $35 per mile of pavement, estimating that each mile of pavement will require about 3,200 bbls. of cement. He has, however, complete control of his materials. He will figure in his cost, the gross cost of cement to the dealer, plus a small allowance for the dealer's differential, less the cost of the empty sacks and less the discount. His purchasing department is already organized to take care of the purchasing and handling of this and any other material and so this would involve no extra cost to him. He is, himself, responsible for the delivery of this material and in case of shortage and non-delivery, he will not be able to file claims against the state for such non-delivery. In furnishing his own cement he is in an advantageous position with railroad companies, as stated before, and he gains both present and future advantages in dealing with certain cement companies and dealers and thus establishes good business relations.

If the state furnishes cement, his bid will be reduced by this net cost of the cement and also by about $135 per mile for smaller bond premium and less carrying charge for financing. He will have to add to this the extra money it will cost on a possible large empty sack loss, loss of the advantages he would otherwise have in dealing with railroad companies, concessions that he might get from good cement company connections, either on this work or future work, and by decrease in his purchasing power and loss of initiative.

It is quite evident that the contractor's profit should be the same, whether he or the state furnishes the material. His costs will be different in the two cases, but his actual organization, equipment, work and risk will be the same; therefore, surely he is entitled to, and his profit should be, the same in either case.

Contractor's Preference.—In conclusion, a responsible contractor prefers to purchase and control all materials entering into his construction work. He serves the purpose of furnishing:

1. Equipment and organization.
2. Necessary finances.
3. Purchasing power for material and labor.
4. Responsibility for the prosecution and completion of the work involved.

For any and all of these, he will function better and more economically than any other agency. A state purchasing material does not avail itself of the purchasing power of the contractor and tends to destroy his initiative and this without any apparent gain. A state purchasing material means government in business. This has proved uneconomical, as we know, and is contrary to the policy of the present administration and the government at large.

National Forests Get $7,500,000 Road Appropriation

Apportionment of the $7,500,000 road fund for the national forests among the States for the fiscal year of 1928, has been announced by the Forest Service, United States Department of Agriculture. The fund is part of the Federal aid road bill.

Four million five hundred thousand dollars was authorized by Congress for the forest highway fund, which provided for the survey, construction, and maintenance of forest roads of primary importance to States and communities; and $3,000,000 was apportioned to the development of roads in and adjoining the national forests of primary importance for the protection, administration, and utilization of the national forests, and necessary for the use and development of the resources upon which communities within the national forests are dependent.

Because of the more extensive areas of national forest land in the West than in the East, the greater portion of the funds has been allotted to Western States. From the highway fund California was apportioned $680,140; Idaho $509,561; Oregon $579,801, and Montana $403,447. Arkansas with $34,472, and Virginia with $17,287, and New Hampshire with $16,437 received the bulk of the appropriation in the Eastern States. Alaska was allotted $472,547, and Porto Rico $597. Of the funds for forest road development Idaho was apportioned $636,277; Oregon $537,103, and California $423,834. New Hampshire with $13,821 was given the greatest allotment in the Eastern States. In the South Arkansas received $50,464 and North Carolina $34,742. Alaska will get $20,562 and Porto Rico $306.

Road Construction in Japan.—A 10-year construction program has been planned by the Japanese government in which the federal government provides one-third of the money needed for construction and the local government units provide the balance of the cost.

Control of Materials and Results in Highway Work

Advantages of Competent Control of Highway Material Pointed Out in Paper Presented Jan. 12 at 24th Annual Convention of American Road Builders Association

By H. S. MATTIMORE

Engineer of Tests and Materials Investigation, Pennsylvania Department of Highways

In the fabrication of any structure, consideration must be given to the fact that its service efficiency will be controlled by many factors, such as suitable materials, skill of workmanship, and of observance of proper precautions controlling good construction. Engineers who investigate pavements or other structures for reasons of defect or failure find that in the large majority of cases it is difficult to trace the failure of an efficiently designed structure to any one cause. Usually, as is the case with poorly controlled construction, a combination of several or all probable errors or evasions can be traced.

Our present discussion is specialized on materials control and the results in highway work. An examination of the highway specifications of any large organization will readily show that material qualities are one of the essentials in such specifications. As these specifications are changed, as a result of experience we observe that if any thing the sections dealing with material qualities are elaborated upon. Therefore, are we not justified in concluding that the use of good materials is considered a major factor in construction? We cannot conceive, at this age, of engineers expecting to obtain an efficient concrete road slab with poor cement or structurally weak aggregate, or a satisfactory bituminous surface with unsuitable material. Some years ago experiments of this kind were tried unintentionally either through inefficient supervision or lack of knowledge. The results of such construction in general were found to be unsatisfactory, as our present state of knowledge leads us to believe would be the case.

"An Interesting Example."—I had an opportunity to observe several of these conditions—for example—a state highway department constructed a concrete road in the outskirts of the city using local sand as a fine aggregate. About a year later the city department constructed the continuation of the same road. To make a more interesting example, the same contractor built both roads, with sand from the same source. The coarse aggregate in both cases was stone of a very good quality. About three years after placing, large sections of the city road were a total failure, while the entire road surface constructed by the state was in excellent condition. Many causes were given for the failure of this road, but the most persistent one was the use of a poor quality sand. The use of a sand from a local pit was commented on by some commercial material producers from the standpoint that no good results could be expected from using material from the so-called wayside pit, but somehow or other the state did secure sand from such a pit which made concrete that gave very efficient service value. A detailed examination of the local sand pit demonstrated that it was possible, without proper control of the material being produced, to obtain an unsatisfactory aggregate, and the probabilities are that the quality, grading and silt content of the sand was a major factor in the failure of the city road.

A Comparison of Aggregates.—An example illustrating another phase of this problem—during the year of 1919-1920, in our own state we constructed one mile of concrete road with a local stone aggregate. A study of the surrounding ledges convinced us during the construction of the highway that the stone was of an unstable character, therefore, the concrete on the five miles of the remainder of the contract was constructed with stone from another source. Both sections of this contract were constructed by the same contractor, under the same engineering supervising personnel, and other than the change of coarse aggregate, the same materials were used. About the third year after completion, the section with the unstable aggregate showed signs of surface rupture. This has been progressive and at the present time, some five or six years after completion the road is kept in suitable condition only at heavy maintenance cost. Meanwhile, the section of concrete with the sound stone aggregate has been in excellent shape for the entire period at average maintenance cost. Constant control, close observation of construction, detailed inspection of the quarry, and of the surrounding exposed ledges, no doubt saved five miles of this road, of which the increased cost of maintenance alone would probably pay for material control on a number of projects.

Other examples of this kind could be quoted, but usually many other factors enter into the cause of failure to complicate the conditions making it difficult to definitely trace the effect of any single cause.

The service value of thousands of miles of highway surfacing under heavy traffic and the difference in service value of highway constructed under different engineering supervision where all other conditions, such as specifications, climatic and subgrade conditions are essentially the same, is a major argument for competent inspection of which competent material control is an essential part.

"Material Control."—Material control is a safe insurance for the use of specified materials. Preliminary tests are essential, but are of little or no value unless some positive check is maintained on the material actually being used. I have never seen a specification for any structure which does not specify material qualities in more or less detail. Such specifications without control may and in many cases do fall short of their intent. For example—in bituminous mixed pavements we specify both the grade and quality of the bituminous materials and aggregates to be used. We know that considerable increase or decrease in the quantity of bituminous material will lead to a failure, and other variations from specifications will have this effect on the service value of the pavement. Experience has taught the highway field that with this type of construction detailed inspections on the quality of the materials and the mixes are aboslutely essential. The reason for this can be readily observed when we compare the results obtained with this type of road in large cities or state highway departments, which have efficient engineering inspection organizations, with other municipalities where inspection is of secondary consideration and of the political brand.

The use of portland cement concrete as a surfacing has led to a large amount of research on concrete and its constituent materials. Many designs for mixtures have been formulated and tried with more or less success. Proportions and grading of aggregates are the foundation of many of these design theories and their application required competent material control.

Water-Cement-Ratio Design. — The water-cement-ratio design, which has been advocated as a concrete quality measure from the standpoint of economy and its ease of application, is applied by maintaining a constant ratio between the water and the cement content to obtain given strengths. An increase of water without increasing the cement proportion would unbalance this ratio and produce a concrete of lower strength. To produce concrete of the maximum strength the water content should be reduced to the amount required to make a workable mix. The

amount of water necessary to produce a workable mix, the cement proportions remaining constant, depends to a large degree in the grading of the aggregate, therefore, it seems reasonable to conclude in the application of this theory that an efficient control to assure the use of well graded aggregates is an economic measure.

Cost of Operating a Material Division.—The cost of operation of a material division whose duties include the testing of all aggregates and supervision of full material field control will vary to some extent at different locations. These costs will be regulated by the type of organization, geographic conditions, and the location of the general material sources of the state, but ordinarily these costs should not exceed five-tenths per cent of the cost of construction, and under some organizations where accurate cost has been kept they have been found to run well under this figure. So considering such operation as an insurance for good construction, it is certainly obtained at low premium rate.

It hardly seems necessary to further emphasize the importance of material control from the standpoint that if it is considered essential for good construction to definitely specify material qualities, why not make these specifications of some value, and be assured that the materials actually used are of the qualities specified. To function economically materials specifications should be based on a thorough investigation so that we definitely know that materials of such quality are or can be produced within reasonable hauling distance.

"Slab Strength of Surfacing."—A step in advance was made in highway engineering within the past year or two when consideration was given to the opening of portland cement concrete roads to traffic, based on the slab strength of the surfacing. A trial in our state of this procedure on selected roads in different locations has convinced us that it is a distinctly forward step. Transverse field tests are made on concrete specimens cast from the mixture being placed, and as a result of these tests wé can definitely determine the traffic carrying capacity of the slab at different periods and regulate the traffic accordingly.

As a result of research of portland cement concrete and its constituent aggregates, we are finding that the slab strength of the concrete road surface is regulated by many different factors, that is, water cöntent, the kind of aggregates, efficiency of the curing and the temperature and humidity conditions at the time of placing and during curing periods. These conditions vary on different contracts, in fact under competent control the least variance is found in material quality, but the other factors are of such importance and are so difficult to control that the concrete being laid on different contracts will show variation in transverse strength. The one big future problem for the highway engineers is to try and secure concrete of uniform quality on all his projects.

Some of these factors are phases of design, for instance—different types of aggregates are available for concrete construction, tests indicate that one aggregate gives higher slag strength than another. If this factor is fully established by research now under way, it seems we might give consideration to classifying roads made with these different aggregates and obtain a differential in bid in locations where traffic conditions would warrant us using a concrete of lower slab strength made with the weaker aggregate.

A Differential in Final Pavement.—Some highway organizations have established a differential in final pavement to the contractors, depending on the riding qualities of the road surface as rated either by straight edge measurements, profilometer ratings or rating of riding qualities obtained with other devices. Other departments test finished roads for depths and deduct for shortage. These are rating qualities of a road which although built under inspection are the direct responsibility of the contractor. We have heard considerable talk within the past few years, and some specifications have been based on the idea of making a contractor fully responsible for the finished work and demanding that it meets certain test qualities before acceptance. At the present time this may or may not work out in practice, as it is doubtful if we have arrived at the stage in highway work where we can expect the contractor to stand fully resposible for quality tests, although I do believe that he can control with good workmanship some of the factors which affect the quality.

A feature that is very noticeable in highway construction is that roads built by different contractors under practically the same engineering supervision are not always deserving of the same rating. I do not refer to major defects or deliberate evasions in specifications, etc. What I especially refer to is at the final inspection at different roads, when a comparison is made one is found to have expectionally good rating while an adjoining road may come within specification allowance and yet is not comparable in finished detail with the first one. The reason for the higher rating on the first road can be traced to variation in workmanship and a general pride in results on the part of the contractor and his employees. Many times it has been noted that the general aesthetic conditions, such as neat slopes, and general appearance is better on one road than another. These are items that are covered by general clauses in specifications, and are difficult ones to attempt rectifying after the work is finished, the general impression being that they are minor details, but every engineer who has responsibility for the final acceptance of any highway contract realizes this. Many times he probably wished some provision existed by which he could either penalize careless constructors or reward the competent contractor who takes pride in his work and always has competent employes.

Public Knows Riding Surfaces.—The traveling public have become educated to differences in riding qualities of different road surfaces, which exist even in roads of the same type. Highway engineers within the last few years are giving special attention to this phase of construction. Some departments as mentioned above penalized the contractor by deducting from his final payment for surface irregularities as rated by specifications requirements.

The next forward move should be to rate the entire road, taking into consideration quality of mixture as affected by mixing, placing and curing, determined by transverse tests for concrete, and density, toughness and absorption limit in Bituminous mixes, riding qualities of all types of surfaces, shoulder and slope finish, which add to the efficiency and appearance of all highways.

Rating of this kind for acceptance would encourage the contractors who take pride in their work and get good detail workmanship, and penalize the class of contractors who work along the lines of only doing what they are forced to do by supervising inspectors, with constant objection to performing operations definitely called for in the specifications.

Fortunately on big operations in highway work of the present day the contractors in the obstructionist class are in the minority, but they still exist. Moves toward their elimination should be encouraged and would be welcomed both by contracting and engineering associations.

I feel that the general contractor's answer will be that present system of awarding public work to the so-called lowest responsible bidder does not encourage the best work on the part of a contractor. The correction for this can be along the line of a better interpretation of the term, "responsible bidder," which at the best, apparently from the legal standpoint, is anyone who can furnish a bond and has control of sufficient capital to carry on the work.

Correction of this kind can and eventually will be made through the contractors' associations with full support of the engineers.

Temporary Roads in Place of Detours.—Georgia has abandoned the use of the term "detour" to mark, or indicate, a road for temporary use by traffic while the main road is under construction. "Temporary Road" is the substitute which will hereafter mark all roads used for traffic while main roads are under construction.

Traffic Control on City Streets

Use of Light Signals in New York City Described in Paper Presented Jan. 20 at Annual Meeting of American Society of Civil Engineers

By PHILIP D. HOYT
Chairman Traffic Board, Police Department, New York City

The feature of traffic control which, in the opinion of officials of the police department, and I believe the public generally, has proved the most successful, is the traffic control light signal.

With the increase in the number of automobiles on the city's streets, the delays due to the crossing of traffic at the various street intersections became more marked. The chief cause of this delay was the lack of co-ordination between the police officers stationed at successive crossings on the same thoroughfare. A car would be stopped at one block to permit cross traffic to proceed and a few seconds later would be halted again at the next important intersection because the officers at the two intersections were not working in unison.

Early Steps to Co-ordinate Vehicle Movement.—As early as 1912 the officials in charge of traffic in New York began to make a study of measures to co-ordinate the movement of vehicles. The first test was made in lower Broadway. An officer stationed at Worth St. and Broadway, which is situated on a slight rise so that he could be seen from Chambers St. on the south and from Canal St. on the north, gave a signal with a flag when he was ready to move cross traffic. The policemen north and south of him followed his signals at their crossings. This idea was abandoned after one day's trial on the theory that the volume of cross traffic varied at the different street intersections.

Experiments to synchronize the movement of cross traffic with semaphores were made in 1915. Each officer was instructed to watch the officer next to him and change the direction of traffic at the same time. The chief difficulty was that the time required to relay the signals over any considerable distance in successive stages was so great that the officers furthest away from the key signal were far behind with their signals. Imperfect as this plan was, it demonstrated that it was a step in the right direction. Later an experiment was attempted to synchronize the semaphores by means of a signal flag at one central point. This was slightly more successful.

Use of Railroad Block Signals.—The suggestion that the railroad block signals could be adapted to the control of vehicular traffic by means of elevated lights soon followed. Some of the older men in traffic were very skeptical of the advantages of such a system, and reports dated as late as 1917 are on file in the police department to the effect that such a plan had no merit. One of the objections raised was that the streets would soon became roadbeds over which the vehicles would speed like railway trains. However, the plan was tried out and its success was instantaneous.

Wooden towers were installed on Fifth Ave. in 1918. Police officers were stationed in these towers to control traffic by means of lights. The towers were built high so that they would be visible one from the other, and the signals were relayed along the system by means of individual controls in each tower.

Four years ago the present bronze towers replaced the wooden ones. The old towers were removed from Fifth Ave. and placed at other points. Many additional towers were installed in various parts of the city in 1923 and 1924.

Pole Signal System Installed.—In 1924 the first system of pole signals was installed. This system had the advantages of not requiring the use of any street space and making possible the operation of many signals over a wide distance from one central point. During the last year 98 signals of the improved pole type were put in operation on 23 miles of streets, and contracts for 173 additional signals covering 22 miles of roadway were awarded. A further program covering more than 1,000 intersections on 66 miles of streets is planned for this year. After this is completed traffic will be controlled mechanically at 2243 intersections in the city, doing the work of 4486 policemen at an annual salary of $13,215,000.

The installation of the traffic lights in this city is under the jurisdiction of the department of plant and structures whose engineers lay out the systems. The police department establishes the locations and plans other details relating primarily to traffic.

The police commissioner in making his latest request for an appropriation to extend the traffic lights, pointed out that in the congested areas of the city every cross street was a danger point both to pedestrians and occupants of vehicles. Most of these streets are thickly populated and thousands of pedestrians have to cross them daily. The careful driver, without this traffic control, must proceed slowly and cautiously, not only to be on the lookout for pedestrians but also to watch for other machines issuing suddenly from side streets. The accident toll on many of these streets has been heavy. While many of the important intersections are controlled by police officers, to provide them at all of the crossings covered or proposed to be covered by mechanical means would be out of the question because of the great cost.

New Zone System.—The experience of the traffic officials with control light signals has led them to plan the new systems in zones. If lights are installed on one of several congested and adjoining avenues, the congestion and hazards on the adjoining avenues without light control signals are greatly increased. To avoid the light-controlled streets, drivers will use the streets where there are no lights, and unrestrained by any traffic control except at the most important intersections where police officers are stationed, speed along without regard to pedestrians or other machines attempting to cross his path. It is deemed better to complete the installation of lights on several adjoining avenues for a shorter distance than to install lights the entire length of one avenue to the exclusion of those adjoining it.

Colors of Lights.—The first traffic light systems in New York consisted of three lights of different colors, red, green and white. This was later supplanted by a system of two lights—green to indicate "go" and red to indicate "stop." The chief difficulty of this system was that the change of lights was so abrupt that no interval was given for clearance. The question of using an amber light as a cautionary light to give warning of changes was considered. Experience of other cities, however, demonstrated that on the amber light vehicles were likely to proceed from all directions. In order to obviate an abrupt change, an interval of several seconds has been provided between the red and green lights, and vice versa. During this period of no light, traffic in all directions must halt. For several months the traffic officials have been experimenting with a system under which the red light will show in all four directions during the interval. This, it is believed, will prove to be the ideal system.

Timing at Intersections. — Several other minor problems relating to the installation and operation of our traffic light systems are yet to be worked out.

One of them is the timing at important intersections. On many of the streets where traffic lights are installed, the volume of traffic on one intersecting street may be many times as great as on the majority of the others. The usual timing that we have is two minutes for the light-controlled street to one minute for the cross streets. But if this ratio is maintained at important intersections, where in many cases the traffic is equally divided between the light-controlled street and the intersecting street, cross traffic would be blocked up over to the river. On the other hand, if the timing at the important intersection were based on an equal division of traffic—say 1½ minutes for north and south, and 1½ minutes for east and west, it would be out of tune with the rest of the system. We have not yet solved that problem. In the meantime the officers at some intersections have to disregard the lights to get their cross traffic through. A particularly difficult problem is where two avenues, both controlled by traffic lights over a considerable distance, intersect. The volume of traffic on the two avenues might be three times greater than on every intersecting street, except the one intersection where the two cross.

The Diagonal Avenue Problem.—Another problem that is giving us much concern is that of diagonal avenues. Broadway, for example, runs diagonally, crossing every avenue from Fifth to Eleventh Ave. In other words, Broadway is both an avenue and a cross street. At every point where Broadway and another avenue intersect both are intersected by an important cross street. The timing on Broadway, as well as the other avenues which it intersects, is two minutes for the avenue and one minute for cross streets.

Now take the intersection of Broadway, Sixth Ave. and 34th St. Thirty-fourth St. has one minute periods in which to move traffic and halts of two minutes while the traffic on the avenues is running. The two minutes have to be shared by Broadway and Sixth Ave. —so that they have only one minute each. This requires a complete break in the plan of synchronization on Broadway and Sixth Ave. Further than that, it requires at each intersection of Broadway with an avenue a special type of traffic light installation. We have been unable thus far to find any satisfactory solution of this problem.

Wave Systems of Traffic.—The operation of the progressive or wave system of traffic control lights such as that on 16th St., Washington, has been studied with considerable interest by the traffic officials of the police department. The chief bar to its use in this city is the fact that most of the streets for which traffic control lights are needed have car lines on them. It is obviously impossible to maintain a uniform and sufficiently high rate of speed when two lanes of vehicles which are given the right of way by the lights are continually compelled to slow up or stop whenever the street cars do so. However, we hope that proper conditions for experiments with the progressive system here may be found.

The progressive principle, however, has been applied with considerable success to cross-town traffic. The average time required to run cross-town from one avenue to another is about a minute. If the light signals on all the avenues are synchronized with respect to each other, the average car will get the signal to proceed at one avenue and arrive at the next one just as cross-town traffic is being shut off. This means a two minute wait at each successive avenue.

By timing the different systems so that an avenue clears cross traffic a minute later than the one west of it, vehicles going east arrive at each avenue just as it is closing for cross traffic. So that, in the zone where this system is now in effect, the vehicle can cover the distance in three minutes with only a few seconds' stop, if any, whereas if the lights were all synchronized he would be moving three minutes and have two-minute waits at each of three avenues—a total of nine minutes. This, as you see, is a reduction in running time across this zone of 66⅔ per cent.

This system does not work the same in both directions, for the reason that the periods given for north and south and east and west traffic are not equal. The waiting time at each avenue for west-bound traffic, however, is reduced from two minutes to one minute, so that the running time for west-bound traffic is cut down from nine minutes to six minutes—a reduction of 33⅓ per cent.

A "Skip Shaker" That Automatically Vibrates Load Out of Loading Skip

A new feature of the 1927 mixers of the Jaeger Machine Co., 719 Dublin Ave., Columbus, O., is a patented skip shaker that starts to vibrate the hopper when it is fully raised and keeps a continual flow of materials into mixing drum. Attachment works automatically and is stated to easily increase the speed many more batches a day and add life to mixer. In addition to this new feature used on both tilting and non-tilting Jaegers many others improvements are found on 1927 lines. The new non-tilt mixer is 100 per cent roller bearing equipped and direct drive (eliminating old style countershaft and brackets), saving over 19 per cent power. Speed reducing gears are heat treated steel running in oil. By building the mixer entirely of steel, the new No. 10-S two bag size for 1:2:5 work is claimed to weigh and cost the same as other one bag mixers. The Jaeger

New Jaeger Non-Tilting Mixer

non-tilters come in 10-S, 14-S, 21-S and 28-S sizes.

The Jaeger tilting mixer also has many new features, such as disc wheels with cushion tires, and auxiliary spring shock absorbers on trailers. Jaeger tilter is built from smallest sidewalk size up to ½-yd. mixers.

Airports and City Planning

The possibility that the airport will shift the trend of city development of the future is broached by John Ihlder, Manager of the Department of Civic Development of the Chamber of Commerce of the United States in an address delivered recently before the City Planning Institute.

Calling attention to the open water spaces possessed by bay cities, Mr. Ihlder said: "It would be difficult to over-estimate the economic value of the breezes from the water that blow through the streets of New York and the bay cities.

"Awakening to the advantages which nature forced upon our fortunate members, we shall provide adequately for the new kind of harbor that is coming to us with the airplane. We doubtless shall, under stress of necessity, figure carefully how small an air field may be, how high the surrounding buildings may be permitted to rise, for we wish to bring the air harbor as far in town as possible in order to minimize change in existing values. But as the railroad induced our river towns to turn their backs upon the levees, so the airplane may induce them to face in a new direction, and those towns which make the most adequate provision are likely to reap a benefit.

"But air-harbors like water-harbors, will prove inadequate to our purpose and other uses, such as truck gardening and farming, will be found for these open areas."

Construction of Bituminous Macadam Pavements

Methods Used in Chautauqua County, New York, Described in Paper Presented Nov. 10 at 5th Annual Asphalt Paving Conference

By SQUIRE E. FITCH

County Superintendent of Highways, Jamestown, N. Y.

For the past three years I have been building bituminous macadam roads for Chautauqua County and I have endeavored to apply the principles, I learned while I was with the state. If these Chautauqua County roads remain as smooth and have as long a life as I expect them to have, it will not be on account of any startling new methods of construction that I have discovered. On the contrary, it will be because of the actual application of as many as possible of the well known principles that engineers have worked out in the past decade.

The methods of construction that we use do not differ much in the essentials from those used in Rhode Island.* The cross-section of our pavement is considerably different. Our roads are too new to have such a long, successful record to point to, as have those of Rhode Island. Nevertheless I have every confidence in them and will therefore tell you, as briefly as possible, how we build them.

Our roads have considerable traffic but are not the main thoroughfares; consequently we build them but 16 ft. wide. In place of being only 8 in. in thickness, as are the Rhode Island roads, we build them 18 in. or more in thickness; never thinner than that.

Costs and Materials.—The average cost of our pavement is $18,000 per mile and that is not greatly different from the cost of Rhode Island roads. Grading, culverts and miscellaneous items bring the cost of the complete road up to $22,000 to $28,000 per mile.

Occasionally a soft local sandstone, with a co-efficient of wear of about 7, is available in ledges, but generally no local materials are available except a poor quality of bank or creek gravel. Crushed limestone and slag are shipped in from Buffalo, some 70 miles distant.

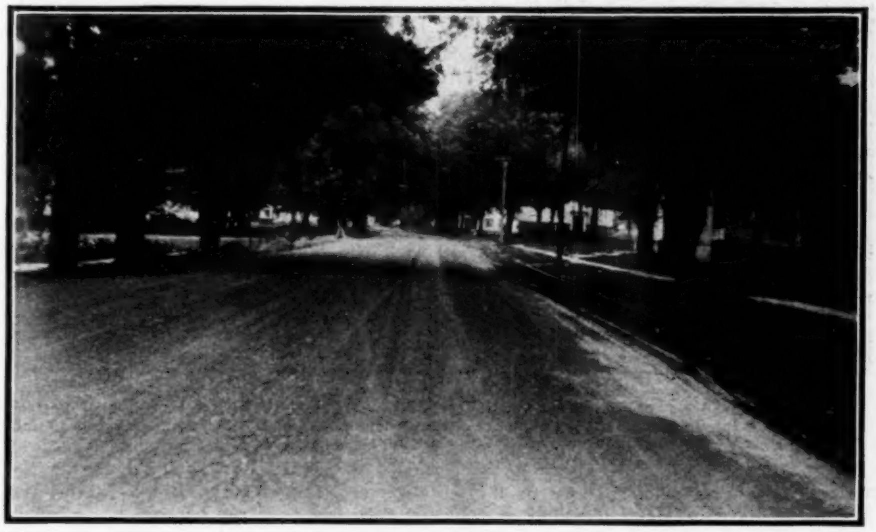
Where the hauls for imported stone and slag are long and the local soft stone is available, it can be used and we do use it for both bottom and top course, but if so used for top course it should be screened to larger sizes than hard stone.

We use sizes between 1¾ and 3¾ in. The tailings and small sizes can be used to excellent advantage for a bottom course. The tailings will readily crush up under the roller and the small sizes make an excellent filler to add while rolling. Where this soft stone is used for top stone, we run the roller over it not more than once or twice prior to making the first pour of asphalt. This is to prevent its crushing up by the roller into sizes too fine to give good penetration of asphalt. The key stone and chips can be made to take the wear by using a slightly greater quantity than usual, with a heavier seal coat. The key stone and chips should be of good, hard stone even if necessary to import them. We find no difficulty in getting any size of local crushed stone we desire by the proper selection of screens. Where the difference in cost is not too great, I prefer to use a good quality of stone throughout the top course because both construction and maintenance will require more care when soft stone is used. A good mat must always be kept over the road to prevent wear coming on the soft stone.

*See Construction of Bituminous Macadam in Rhode Island, December, 1926, Roads and Streets.

12 In. Gravel Foundation.—We use 12 in. of run-of-bank gravel for a foundation on the entire road.

We use 5-ton trucks for hauling gravel and they will quickly show up any weak spots in the road, better than a 10-ton roller. Where such spots are encountered, or expected, we at once put on an extra course of gravel over these spots and haul the rest of the gravel over it. If this does not strengthen it enough, we add another layer of gravel until the road is firm. We then put the regular two 6-in. courses of gravel on top of it all, raising the grade line where necessary. The gravel is loaded on hired trucks by steam shovels. It is spread with mechanical spreaders, rolled with 10-ton rollers, continually smoothed up with small 1-man graders built around Fordson tractors. From 300 to 600 cu. yd. is put on per day at an average cost of a little over one dollar per cu. yd. in place, or $4,000 per mile. We prefer to let the gravel stand over winter before putting on bottom and top courses, but usually this cannot be done. When this gravel foundation is firm enough to hold up loaded 5-ton trucks without movement, we lay a 4-in. loose, or a 3-in. consolidated bottom course of slag crushed between 2½ and 3¾-in. sizes. We roll the slag thoroughly, adding slowly a fine dirty gravel for filler.



View of Frensburg Road—An Old 9-Ft. Waterbound Macadam Road Widened to 16 Ft. A 12 In. Gravel Foundation Course, 7 Ft. Wide on Sides; a 3-In. Slag Bottom Course, 16 Ft. Wide, and a 3-In. Limestone Top Course, 16 Ft. Wide of Penetration Asphalt Construction, Using 2¼ Gal. Per Square Yard. The Cost Was $17,500 Per Mile

This bottom course also costs $4,000 per mile. When this is as firm as a waterbound macadam, we lay a 4-in. loose or 3-in. compact course of crushed limestone, poured with 1¾ gal. of 110 penetration asphalt, keyed with ¾ to 1¾-in. limestone. For a seal coat we use ½ gal. of asphalt and I prefer to have this seal coat of 150 penetration. Limestone chips, and plenty of rolling and back-rolling, completes the operation.

Work Done by County Forces.—We keep our costs down by doing the work with county forces, by using modern machinery, and by avoiding hand labor wherever possible. I know many of you are skeptical of departmental work. I was once skeptical of it myself. I know

what you are thinking about my overhead not being included in the costs. It is so included but I haven't time to go into the question of departmental work here. I will confine myself to saying if your department is as free from political influence as ours is, a good departmental organization, if not too large, can save money over contract work. Don't try it though unless you are free to hire and fire whom you please.

Our excavation is done by steam shovels, supplemented by trains of four 1¼ yd. self-loading scrapers pulled by 10-ton caterpillar tractors. The fine grading and most of the trimming is done by one-man blade graders built around Fordson tractors on crawlers. Our stone and slag is unloaded by mechanical unloaders into bins. All gravel, stone and slag is hauled by hired trucks paid for on the cubic yard mile basis. The price varies for hauling each material on each road and is established by a diagramatic chart which is so drawn that a Liberty truck can earn $3.00 per hour provided it loses no time. By hiring trucks in this way we avoid paying for lost time. This is better than letting a contract for the hauling because we can put on as many trucks as we please and can weed out the poor ones which detain the others.

We spread our stone, slag and gravel with mechanical spreaders. Each truck carries its own chains, hitched on and adjusted so that the chains are the proper length to drop the hooks into the rings of the spreader.

Applying Asphalt.—We pour asphalt with motor distributors. Just prior to pouring we blow out the nozzles and manifold with live steam conducted through a steam hose from the roller to a tap which we have installed between the tank and manifold. This cleans out and heats the pipes and nozzles before the distributor starts. To avoid having the truck wheels of the distributor make ruts in the top course by their tractive pull, we pull the truck with a steam roller for the first pour and adjust the governor of the roller to give the exact speed desired. Like Mr. Henderson, we try to make each succeeding course smoother than the one below. We agree with him entirely that it is impossible to build a smooth top on a rough, uneven bottom course.

These roads ride well and I believe will last as long or longer than many roads of other types that cost nearly twice as much. My reason for thinking they will have a long life, aside from the fact that we take pains in the details, is on account of the thickness of pavement.

Difference Between Chautauqua County Roads and Rhode Island Roads.—The main points of difference between our roads and those of Rhode Island are as follows:

The standard thickness of Rhode Island roads is 8 in. plus the extra foundation under soft spots.

Our roads are 18 in. thick plus the extra foundation under weak spots.

The Rhode Island top course is 2½ in. thick while ours is 3 in. thick.

The Rhode Island bottom course is 5½ in. thick while ours is but 3 in. thick.

Rhode Island uses 2½ gal. of asphalt of 85 to 100 penetration on a 2½ in. top course.

We use ¼ of a gallon less per square yard on a top course ½ in. thicker. We do it by reducing the seal coat to ½ gal. We use asphalt of 100 to 110 penetration.

Inasmuch as bottom course is cheaper than top course and 2½ in. of top seems to be satisfactory in Rhode Island, it would seem that we might save a little money and not sacrifice strength by increasing our bottom course from 3 in. to 4 in., and reducing the top course from 3 in. to 2½ in. I am also willing to grant that asphalt of penetration 85 to 100 will produce a firmer road than will asphalt of 100 to 110 penetration. However, if I used a penetration of 85 to 100 in New York State climate, it would be only for the first pour. My seal coat would be but ½ gal. with a penetration of about 150, for reasons I will explain later.

I do not know how much gravel or sand is available in Rhode Island nor do I know how much it would cost per cubic yard there to put it in place, for a foundation under the whole road. If Rhode Island has anything at all to learn from our practice it would perhaps be to reduce the bottom course to 4 in. and put an extra foundation course of cheap local material under the entire bottom course. It would have to be of some cheap granular material obtained nearby the road and very likely it is not available. Her 8-in. roads no doubt carry present day loads in a satisfactory manner but the factor of safety is probably not very large. Extra thickness of pavement, if it can be obtained cheaply, might well be worth while as a safeguard against increased loads.

County Farm Road No. 59, Constructed with 12-In. Gravel Foundation Course, 3-In. Slag Bottom Course and 3-In. Limestone Top Course of Penetration Asphalt Construction, Using 2¼ Gal. Per Square Yard. The Cost Was $26,000 Per Mile

Wayne County, Mich., Will Construct Roads by Assessment System

Construction will be started in April on the first highway to be constructed by the Wayne County, Mich., Road Commission, under the assessment system.

Beginning this year, through the creation of special assessment districts, the commission begins to construct roads in which owners of adjacent property will share in the cost. Heretofore it has been the policy to pave all highways with funds derived from the sale of automobile licenses.

A concrete highway, 15 miles in length, costing approximately $800,000, is the first job to be undertaken under the new plan. The first two miles will be built on a 204-ft. right-of-way and will have two 20-ft. concrete roads for one way traffic. Where it veers to the west the highway will be one 20-ft. strip of concrete, on a 120-ft. right-of-way.

It is stated there will be comparatively little tax burden on property owners, because payments will be spread over a 10-year period. Operations will be carried on under the Covert Act. In the case of the road, it was decided that 50 per cent of the cost is to be paid for by the district and the balance by the townships and county, the major portion being assessed against the county. The bonds will run 10 years. Any property owner, however, has the privilege of paying his assessment in one installment, thereby saving interest.

Patching Small Openings in Asphalt Paving

Methods of Repairing Pavement Cuts Described in Paper Presented Nov. 10 at 5th Annual Asphalt Paving Conference

By WALTER E. ROSENGARTEN
Traffic Engineer, The Asphalt Association, New York

It is estimated that in this country there is something in the neighborhood of 650,000,000 sq. yd. of mixed types of asphaltic surfaces. If the maintenance and patching area is 1 per cent per year it means that some 6,500,000 sq. yd. are laid annually in small and scattered patches, numbering probably a million. While it may seem a trivial matter to discuss the patching of a small opening it is indeed a big proposition in the aggregate, and if it can be properly and expeditiously accomplished it means a comfort and service to the travelling public.

In the Borough of Manhattan, New York City, for the year 1925, there were openings totaling 78,532 sq. yd. cut in the asphalt pavements for work on underground structures. This is a little over 1 per cent of the total area. This is typical of the condition throughout the country. An English writer has called this "trench fever." It is indeed a contagious and expensive disease, but there is little wonder when it is recalled that beneath our pavements is a network of water, gas, electric, telephone, sewer and steam lines. Frequently the number of openings is increased due to indefinite mapping of these structures. An endeavor should be made wherever possible to so lay out underground pipe lines and services to eliminate the necessity of openings in the paved area. A central park area in the wider streets is an ideal location for pipe lines. Some localities have laid piping under the sidewalks, and a worthy suggestion has been to make the curb a box conduit for electric service and small pipes. The street lighting would very conveniently be served in this manner.

Regulation of Openings.—It is highly desirable that openings in pavements be kept at a minimum. A usual method of reducing the number of openings in a new pavement is to notify the abutting property owners personally, or post signs along the street, prior to beginning work, requesting that all repairs to underground structures be taken care of immediately, as a pavement is about to be laid, and that no opening will be allowed thereafter for one year. While it is impossible to strictly enforce this regulation it will assist materially in the elimination of many unnecessary openings.

There are many openings which cannot be held off until the time of repaving, such as repairs to faulty piping and extension to systems, due to the developing of the community. These necessary openings should be regulated and a method which is giving good results is for the city to charge the owner or public utility company for the cost of replacement at a fixed amount per square yard for openings in the various types of pavements. The public utility company, or owner, is then allowed to make the opening and the city forces called in for backfilling and repaving. Thus the city has full control and responsibility. Another method is for the party making the opening to be allowed to replace the fill and paving upon a deposit of double the estimated cost. This excess is retained for six months. The extra deposit insures care in tamping backfill and paving. Before replacing the paving it is desirable for the base to be cut back with a vertical edge, sufficiently to leave an undisturbed shoulder of the old subgrade of at least 4 to 6 in. all around and the asphalt surface cut back 2 to 3 in. further.

In relaying the paving a rule which should be followed is that the materials and construction should be as near like the surrounding pavement as possible. If this is done there is less likelihood of a bad place forming and the existence of the patch will also be less noticeable.

For the larger cities who have their own asphalt plants or who have sufficient work to keep a contractor with a hot mix plant in continuous operation, the question of repairs is not so difficult. For the small city, where a hot mix plant is not available, the question of properly repairing openings is sometimes considered a more difficult problem. This should not be the case today when there are available small repair plants for preparing hot mixtures, as well as asphaltic materials, which can be handled cold.

The problem which confronts the engineer or official in charge of maintenance of asphalt surfaces of the hot mix type is the fact that patches and repairs are required at odd times and must be laid in small areas. The quantity of material required at any one time does not justify setting up and starting in operation a full size hot mix plant. Repairs in a sheet asphalt or an asphaltic concrete pavement should preferably be made with a hot mix of similar grading and a slightly harder asphalt than that used in the original construction. There is no need for an opening to be left unpaved for any period, as a temporary patch can be readily placed. These may be of penetration type, or preferably a mixed type. Cold asphaltic binders may be used for this purpose.

Cold Mix Materials.—The asphalt binders which can be mixed cold at ordinary temperatures may be classed into cut back asphalts and emulsified asphalts. Ready prepared asphaltic mixtures are also on the market which can be laid cold.

The cut back asphalts are made from standard grades of paving asphalts, which have been softened by combining them with a light petroleum product, such as naptha or gasoline. These are workable at ordinary temperatures. About two-thirds of a gallon is mixed with a cubic foot of stone chips to form a paving material. It may be kept in stock piles for long periods and when needed can be readily spread out on the road surface in a thin layer. Initial stability is obtained through the mechanical interlocking of the aggregates when rolled. The light volatile material then evaporates rapidly, leaving the hard sticky asphalt to bind the mix firmly in place and thus insures the necessary stability for modern traffic. If desired these materials can be easily prepared on the job, the mixing being accomplished either by hand or in a small portable hydraulic cement mixer. A satisfactory method is to stock the materials at the department yards and provide a covered place where mixing can be done on rainy days. It is preferable to allow the material to stand for a short time after mixing to stiffen somewhat so that it will hold its place better when first spread on the road.

Specification for Cold Patch Asphalt.—A material suitable for this work is covered by the following tentative specification, which has been carefully prepared by the Asphalt Association:

Cold Patch Asphalt

Specification M-1, Jan. 12, 1926.

The cold patch asphalt shall be homogeneous and free from water. It shall meet the following requirements for physical and chemical properties:

1. Specific viscosity Engler at 122° (first 50 cc.) 30 to 70.

2. Separation of Asphalt Base from Distillate Flux.

a. Distillate by volume:

Per cent off at 374° F.	Not less than 10
Per cent off at 437° F.	Not less than 15
Per cent off at 680° F.	Not more than 35

b. Characteristics of residue from distillation to 680° F.:

Penetration at 77° F., 100 g., 5 sec.	50 to 150
Ductility at 77° B.	Not less than 30
Per cent bitumen, soluble in CS.	Not less than 99.5

Methods of Testing:

Specific Viscosity Engler, U. S. Dept. of Agriculture, Bulletin 1216, P. 59.

Separation of Asphalt Base from Distillate

Flux (Special Method Issued by the Asphalt Association).
Penetration, A. S. T. M. Standard Test D5-25.
Ductility, A. S. T. M. Tentative Test D113-22T.
Bitumen, soluble in CS, A. S. T. M. Tentative Test D4-23T.

Emulsified Asphalts.—The second class of asphaltic materials for cold working are known as emulsified asphalts. These are prepared by treating ordinary paving asphalt with a saponifying agent so that it will mix with water. These emulsions contain about two-thirds asphalt and one-third water. They are handled in a manner similar to the cut back asphalts. It is not necessary that the aggregates be dry when mixed with emulsified asphalts. About one gallon is used for each cubic foot of aggregate. The latter can be made up of two-thirds of ¾ in. stone and one-third ⅜ in. screenings. The small inclined axis type of mixer gives better results and less trouble from balling than the horizontal axis mixing machines. Care must be used not to over-mix when this material is used, as there is a possibility of the water and asphalt separating. Until recently freezing would also damage emulsified asphalts by causing their separation. However, a material is now on the market which overcomes these disadvantages and can withstand freezing weather without injury. This material has been carried through the winter without impairment. The emulsified asphalts are excellent for cold patching work and, while it is recommended that a hole be cut with vertical edges to more securely hold the new material in place, many successful patches have been made by lightly painting the surface of a depression, or disintegrated spot, with emulsified asphalt and filling with a mixture of stone and emulsified asphalt which is spread to a thin edge.

Ready mixed materials are available which make unnecessary mixing plants and machinery other than the shovels, rakes and tampers or rollers. These are generally mixed at quarries or central mixing plants and shipped in carload lots. They may be stored in stock piles and used as needed. Old asphalt pavement is sometimes re-used for temporary patching. It is broken into small pieces of 2 to 3 in. size and heated in kettles with about 5 per cent of water. It is allowed to steam for half to three-quarters of an hour and the plastic mass then is spread in the opening and compacted. This practice is used in several of the larger cities for winter patching. Some places pass the old material through an asphalt plant and add fresh asphalt or sand as needed to improve it.

It should be considered that these cold mixtures and reheated materials make very satisfactory temporary patches to hold for a time. When sufficient patching of this character has been carried out it is desirable to arrange for a hot mix plant to come in and replace the temporary patches. This requires additional cost but it is compensated by the fact that no period of obstruction to traffic need exist. The more lasting hot patch of carefully graded aggregate will blend more readily with the surrounding pavement, making it practically unnoticeable after traffic has passed over it for a short period. It is possible by the use of suitable equipment to make hot mix patches for small areas.

Since it is desirable to replace an opening as promptly as possible, some cities have been successfully cutting down the period of obstruction to traffic by constructing the base of asphaltic concrete in place of portland cement concrete. It is laid in courses of not over 4 in., each thoroughly tamped. On this the surface is immediately placed by the same gang laying the base, using the same equipment.

Equipment for Mixing. — Excellent patching of the mixed asphaltic pavements can be accomplished with inexpensive equipment. Materials can be mixed by hand and little more than a mixing board, shovels, rakes and tamps required. When a few square yards are patched at infrequent intervals, as in small towns where but a few streets are paved, creditable work can be done with this simple outfit. It is of course desirable and economical to have additional equipment if any appreciable area is to be maintained. A variety of equipment is on the market which will suit almost any need. For heating the asphalt there are a number of small portable kettles burning wood or oil. Aggregates may be heated over pipe containing fire, but there are small portable heaters for this purpose. A compact portable maintenance outfit which is being used extensively includes a body with compartments for sand, stone and asphalt, a heating furnace and a hand mixing pan. With this a gang of four men can patch about 80 sq. yd. per day. For cold weather work a special wheelbarrow equipped with gasoline heating torch, in which hot materials can be mixed and transported will be of assistance. For mixing of the cold patch and emulsified materials the small concrete mixers may be used. For hot mixtures a compact, well equipped portable unit with open top continuous blade mixer, rotary sand drum heated by kerosene burners, air compressor, etc., operated by gasoline motor can be purchased for about $5,000. It can be operated by a mechanic and one laborer who can turn out 125 sq. yd. per day. If the area to be maintained is large a small size, completely equipped portable asphalt plant will undoubtedly be desirable. Several plants of this character having outputs of from 350 to 800 yd. per day are on the market at a cost of $7,000 to $12,000. Generally they are mounted on a rubber tired trailer for easy transport; heat is furnished with fuel oil burners and power by a gasoline motor.

A handy piece of equipment for maintenance work is the surface heater. This consists of a hood which confines and directs hot gases upon the pavement. After a few minutes the old surface is sufficiently soft so that it may be scraped to a depth of ¾ in. and new material applied. In this way humps and depressions may be leveled and disintegrated places renewed with the use of a very small amount of new material. The surface heater may be obtained in several sizes, the smaller machines mounted on two wheels and hand propelled, while the larger ones are on a truck or tractor chassis.

New Street Lighting at Columbus, O.

The City of Columbus, O., is taking the initial step toward the adoption of a uniform lighting system. The main business district of High St., the main thoroughfare of the city, is to be equipped with intensive white way units, the secondary business district of the street with less intense illumination, and still another type of the same general design for the residential part of the street, beyond the business section.

More than 500 lighting units of four types are to be installed along the street. Of these, the main business section will include 96 twin units, with blue-tint medium alabaster ripple globes and canopies. The lamps will be of 1,500 candlepower each, with light centers 20 ft. above the ground.

In the secondary business section, 166 units will be used. These will be equipped with 1,500 candlepower lamps, at a height of 16 ft. They will have medium alabaster ripple globes and canopies.

Between the secondary business and residential sections there will be 18 units with 1,000 candlepower lamps, to prevent too great a decrease in intensity of illumination such as would prevail if 600 candlepower lamps were placed next to 1,500 candlepower units. Except for the lamps, the units will be similar to the 166 units of the secondary business section.

The 143 units for the residential section will be equipped with 600 candlepower lamps, and will have light alabaster ripple globes and canopies, with asymetric dome refractors. Lamp centers will be 13 ft. above ground.

Each single-light standard will be equipped with a disconnecting pothead type of IL transformer, and each twin light standard will have two such transformers in the base, one for each lamp. There will also be 17 subway type RO transformers, six subway type contactors, and two automatic pole type contactors.

All of the electrical equipment will be supplied by the General Electric Co., and the poles, except where the old posts are being remodeled, by the Union Metal Manufacturing Co.

Practical Qualifying of Bidders in Public Works

Illinois System for Determining Qualifications of Contractors Described in Paper Presented Jan. 13 at 24th Annual Convention of American Road Builders Association

By FRANK T. SHEETS
Chief Highway Engineer, State Division of Highways

The protection of the public from the irresponsible contractor has become a problem of great importance. A survey of public works contracts executed throughout this country during the past ten years will show a long procession of disastrous failures of contractors. These failures have brought sorrow and suffering to the family and friends of the contractors themselves; they have cost the public millions of dollars in inconvenience and delay; and they have caused the bonding companies who have furnished bonds to suffer losses which have been automatically passed on to the entire construction industry.

An occasional failure is inevitable. Sudden changes in economic conditions, transportation facilities, or adverse physical conditions when combined with the inelasticity which surrounds necessarily all public work contracts may wreck an absolutely reliable, experienced, and financially capable contractor. However, the majority of contractors' failures have been directly traceable to inexperience, lack of funds and lack of proper equipment. The novice in the construction industry and the reckless plunger must be saved from themselves and the public saved from them.

Irresponsible Bidder Costly.—I have seen instances where an irresponsible bidder has been awarded contracts slightly under the figures of a responsible bidder and the resulting inconvenience, and delay caused by his failure has cost the public a hundred times more than the difference in the bids. These conditions and these problems have become more and more pressing as the volume of public work has increased. It has been the custom for the surety bond companies, the material producers, the banks, and the contractors themselves to cry aloud in anguish over the lack of vision of the public official in awarding contracts to irresponsibles. At the same time, each of these agencies have perpetuated practices and policies which have made the path of the novice, the crook, and the plunger one of roses, and have forced the public officials to stand the gaff of public criticism and even suspicion of his integrity if he were to carry out the dictates of his unbiased judgment in the elimination of irresponsible bidders.

What justification is there for the public official, who values his reputation and who has tried to build a record of square-dealing, to jeopardize his reputation and his future by tackling single handed a problem which the construction industry at large yells about but leaves strictly alone? I declare that the public official as a whole has done more to stabilize the construction industry than the members of the industry themselves.

The Illinois System.—In the Illinois Department of Public Works and Buildings, Division of Highways, we have faced this problem and have tried to meet it. Our laws require that our contracts be let to the lowest responsible bidder. We have realized fully that no arbitrary determination of the responsibility of a bidder could be made without suspicion of our motives. Therefore, some years ago we adopted a form of financial statement and experience and equipment questionnaire which we required each bidder to submit with his proposal for our consideration. We established, as a result of our own judgment and the judgment of a large number of reliable constructors, the minimum financial qualifications required for the execution of contracts of various sizes; we determined from years of experience the minimum requirements of equipment for various sizes of contracts; we analyzed carefully the prearranged plans for the contractor for handling every project; and with all this data for our guidance we have determined the responsibility of our bidders. Sometimes our judgment has erred, and an apparently responsible bidder has failed during the test of construction, but considering the fact that we have carried on over $150,000,000 worth of road contracts during the past few years since adopting this policy, the number of failures is gratifyingly small. We are still following this practice, and when we determine that a bidder is irresponsible, we write him a letter rejecting his bid and include in that letter a complete recitation of the facts upon which this judgment is based—these facts being taken from his sworn statement. We are willing to publish this letter to the world in case our motives are questioned or we are charged with favoritism, but we have not had to do so.

Making Responsible Contractors.—In many instances when we have rejected a bid, we have suggested to the bidder that although his qualifications were not sufficient to justify awarding the specific contract in question, further bids on smaller and less hazardous work would be welcome, and we have been pleased to see many such contractors develop to the point where they can now tackle most any project we submit.

The questionnaire which we are now using is the standard adopted by the American Association of State Highway Officials and embodies practically all of the features of our original questionnaire. The development of this questionnaire by the joint committees of public officials, contractors, bond writers, and other members of the highway industry has been a distinct contribution to the construction industry and I commend it most heartily for use by every public official. We have absolutely proved its value and would not be without it. It is interesting to note that in the awarding of the above mentioned large volume of contracts by our department not a single suspicion of favoritism nor charge of wrong motive has arisen.

Embarrassing Situations.—It is only fair to say, however, that sometimes the use of this questionnaire has caused us embarrassment in that we were forced to battle away at this problem alone when the course of least resistance would have been much more pleasant. Many times when the questionnaires submitted by bidders have shown them to be absolutely unqualified for the work they were seeking, we have had reputable surety companies state their willingness to write surety bonds for the bidders in question, and in some instances these companies have urged us to make such an award. It seems inconceivable that a bonding company would be willing to gamble their money on an irresponsible bidder unless the irresponsible is figured into their mortality rates; and if this is true, it is an unhealthy condition which is unfair to the responsible bidder.

Formerly this department used to permit the submission of bidders' bonds instead of certified checks in connection with proposals at road lettings. Consistent securing of such bonds by irresponsible bidders led us to discontinue this practice and instead to require that certified checks amounting to 10 per cent of the bid be submitted with all proposals. We were somewhat dumbfounded when we were informed reliably that representatives of surety companies had engaged in the practice of securing certified checks for bidders in order to get the jump on the bond business. It is apparent on the face of it that any bidder who cannot raise enough funds to secure a certified check deserves not only sympathy but also protection.

Bankers Too Liberal.—It has also been a revelation to us how liberal the

banking element of our citizenship has been in dealing with the irresponsible bidder. I sometimes feel that some of these bankers have made a bad loan to begin with and are still sending good money after bad in the hope that events will break in their favor. In some of our most questionable cases, banks have been willing to state that they were ready to extend a liberal line of credit to the bidder. I know of one instance where this was done and although the contractor executed an assignment of payment estimates to the bank, the bank neglected to file the assignment with our department. After all payments had been made and the contract closed, the assignment was presented for our consideration with the result that the banker has gained some valuable experience in how "to hold the bag." If our bankers could be as "hard boiled" in such cases as seems to be customary with the average citizens, the construction industry would be better off.

How marvelous it is also that manufacturers of equipment and producers of material seem quite willing to extend the same business courtesy and line of credit to the "would be" contractor that they do a firm with millions of dollars of successfully completed work behind them and plenty of cash in the bank.

Allowance of Material Estimates.—In order to minimize the interest charges necessary to complete state road contracts we have allowed payment estimates on materials delivered on the ground but not incorporated in the work. This policy has met with the enthusiastic approval of our most responsible contractors. Yet it seems strange that some of our contractors who are very weak financially have been able to buy materials without making assignments of these estimates and have then been able to use these estimates for current funds to finance labor and machinery payments while the material company blandly waited for the cash. Verily, verily, competition is keen.

The machinery companies have also been most sympathetic and brotherly in their treatment of the irresponsible contractor. I know of one instance where the machinery was delivered on the job on a time payment basis. The contractor then went to the bank and borrowed money with which to run the job and put up the machinery as collateral to secure the funds. For ingenuity in financing, this is almost unexcelled.

Fair Prices.—We have insisted on absolutely fair prices for road work. This is evidenced by the general price reduction which was brought about some years ago after several months of controversy. When I say fair prices that is what I mean. We do not want contractors to do road work in Illinois and lose money, neither do we want them to make more than a fair profit. We have insisted on clean, keen, and open competition and our bids have proved that this exists. However, after some of our most experienced and strongest contractors have taken work at figures which are most gratifying to the state but which cause us to look with admiration and even wonder at the contractor in question, we have been somewhat astonished to have him explain that he took the work in order to keep his equipment busy. Yes, indeed, depreciation is a wonderful thing, and occurs much more rapidly when the equipment is properly greased and stored than when subjected to the shock of operation and the grit of road grime!

Why fuss at public officials about the low prices at which the public work may be let when the most responsible men in the contracting business repeatedly establish such prices. Either the prices are right and the lament is wholesome propaganda, or the contracting industry needs to clean its own house.

No Numerical Limits.—In this discussion I have not attempted to set up definite numerical limits nor mathematical formulae for establishing the responsibility of a bidder. I may have treated the subject from the prejudiced viewpoint of the public official, battling wearily with a seemingly endless problem; I may have cited certain horrible examples which are the exception rather than the rule; but if I have been able to stimulate the courage of the men in charge of public affairs; if I have been able to prick the conscience of the banker, the machinery manufacturer, the material producer, the bond underwriter, and the responsible contractor; if I have been able to warn the embryo contractor that he must learn to walk before he can hope to run; then this paper will have served its purpose.

I congratulate the field that conditions are no worse. I declare that they can be made much better; and I urge all elements of the construction industry to proceed sanely, rationally and intelligently to a solution of this most important and perplexing problem.

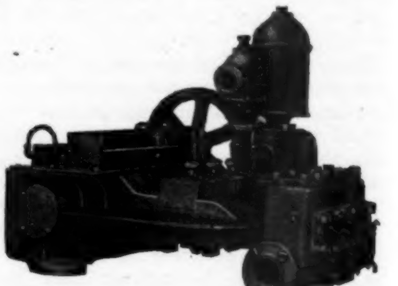
New High Pressure Force Pump

A new heavy duty high pressure force pump has been brought out recently by the Domestic Engine & Pump Co., Shippensburg, Pa. This new pump is a large capacity, high pressure, three cylinder, self-oiling, single acting plunger pump. The packing is held stationary by outside adjusting packing glands. These glands are equipped with compression grease cups so packing can be kept properly lubricated.

Special features are automatic force feed oiling of all connecting rod and drive shaft bearings; steel gears; machine cut and running in oil; Hyatt roller bearings on high speed drive shaft; closed crankcase to keep out dirt and retain oil.

The large diameter steel, three throw, crankshaft is finished by grinding all bearing surfaces. Oil is forced through drilled hole in shaft direct to connecting rod bearings.

Valves and valve seats are bronze. Valves have 45° angle seating face and are practically self-grinding. The valve



"Giant" Heavy Duty Force Pump

caps are equipped with adjustable stops to regulate the lift of valves.

Air chamber, water relief valve, pressure gauge and flanged unions for both suction and discharge connections are furnished as regular equipment.

This pump is regularly furnished powered by a 35-h.p. 4-cylinder, industrial type gasoline engine with friction clutch and mounted on steel wheel, spring type trailer. Maximum working pressure is 600 lb.

Conference on City Paving

A meeting will be held at the Engineer Club of Philadelphia, 1317 Spruce St., Philadelphia, Pa., on Feb. 15 to discuss the subjects of "Strengthening foundations for highways and city streets to meet the growth of motor bus and truck traffic," and the "most economical method to effect the strengthening." The program of the meeting follows:

Afternoon Session 2 P. M.

Introductory Remarks—Julius Adler, Presiding Officer.

Outline and Comparison of Present Available Methods for Strengthening Foundations, by Frederick W. Lyon, Chief Engineer, Dept. of Public Works, Pittsburgh.

Survey of Present Situation in City of Philadelphia, by J. H. Neeson, Chief, Bureau of Highways, Philadelphia.

Survey of Present Situation in City of New York, by R. A. MacGregor, Engineer of Maintenance, Boro of Manhattan, New York.

Comments on Conditions Existing in Seaboard States South of Pennsylvania, by C. B. Hunt, Engineer of Highways, Washington, D. C.

Dinner ($1.00) will be served in the Club House from 5:30 to 6:30 p. m.

* * *

Evening Session—7 p. m.

Introductory remarks—George H. Biles, Presiding Officer, Director, Dept. Public Works, Philadelphia.

Quality Control of Concrete for Pavements and Pavement Foundation, including a Brief Review of Impact Studies of the Bureau of Public Roads, by F. H. Jackson, Engineer of Tests, Bureau of Public Roads, Washington, D. C.

Studies of the Dept. of Highways on Pavement Slabs and Strengthening Foundations, by P. M. Tebs, Headquarters Field Engineer, Dept. of Highways, Harrisburg, Pa.

Miscellaneous Special Methods of Improving Foundation Support other than by Increase of Thickness, Enrichment of Mixture, or Use of Reinforcement.

Increasing Efficiency in Highway Construction Organizations

A Paper Presented Jan. 13 at the 24th Annual Convention of the American Road Builders Association

By J. L. HARRISON
Highway Engineer, U. S. Bureau of Public Roads

Among engineers it appears to be the prevailing assumption that when a contractor wants more work, he looks over the list of approaching lettings, determines, what work he would like to have, sharpens his pencil for a bit of nice estimating, adds a fat profit, and, presto, has his next job. All of you have heard some version of this many times and perhaps some of you—even some of you gentlemen who are on the contractor's end of this game—really believe it. But like so many of the honored platitudes, this one is pure bunk. What contractors actually do, as most of you know, is to study the market—and there is a market for every type of highway work just as there is a market for cotton or copper or corn. The farmer doesn't figure the cost of raising corn, add to this a profit and so determine his selling price. He sells at the price the market sets and then works overtime to produce his next crop at a cost which will yield him a profit. If he can't do this he simply goes broke and that ends it for him! Some other chap steps in and tries to prove that he is smarter and so can get a profit where the other fellow failed. The ranks are never depleted though the men in the business change.

Studying the Market.—The market—the price at which others will do a given piece of work—sets the price which you, as a contractor, can obtain for doing it. To get the work you study the market—that is unavoidable. You cannot get dirt at 30 ct. if your competitor will do it at 25 ct. You cannot get concrete at $3 if the fellow whose office is next to yours is willing to do it for $2. You have to meet him on the $2 price or go out of business—difference whether you think you can get a profit at that price or not. You have to take it at that price if the other fellow will or you have to go into some other business!! And, like the farmer referred to above, after you get that $2 concrete you may be no better ness! It doesn't make a particle of off than Betsy and the bear. You have all heard of Betsy—she who so blithely called on brother Tom to help her catch the bear and then, having caught him, called mightily to the whole town to come and help her turn him loose!

Competition and Efficiency.—No, to get a job you don't spend much time in estimating the cost of doing it. But you spend a lot of time in speculating on what Harry—or perhaps it is Tom—is going to bid on it and also as to whether the market price is likely to go up or down. That is unavoidable under our competitive system. But after you have gotten the job, you want a profit—a good profit. But to get it—that is a very different hing!! Now that pencil which was supposed to have been used so skillfully in making the estimate on which your successful bid rested, but which was really used only when the proposal sheet was filled out, can be called on to astonishingly good

Don't Set Your Bins So That the Trucks Must Back Under. Backing and Maneuvering Takes Time and in Contracting Time Is Money

advantage. To obtain that profit the highest efficiency must be had. And efficiency is not accident. Neither is efficiency a synonym for energy or enthusiasm. As a matter of fact, efficiency ordinarily results only from careful systematic planning, from the determination of some specific course by which a desired result can be had and then from setting about with tireless persistence to follow that course. No, efficiency is not an accident. It is, if you please, the result of good management and management means head work and hard work—and lots of both of them.

Planning Operation.—Now that last concrete paving job was taken at $1.95 because you were certain that Harry would bid a shade under $2. At that price, it is going to be necessary to cut all the corners to obtain any profit at all. There must be efficiency in every operation and nothing can be lost. But to bring this about, the first thing that must be done is to prepare a plan of operation—a definite course to be followed—which, if followed, will obtain the desired results. A good plan of operation tends strongly to protect profit. A poor plan throws away profit before even so much as a pick is stuck into the ground. In a brief discussion such as this, the details of planning cannot be treated at any length. It may, however, be remarked that to the successful execution of a contract, a plan is as essential as sailing directions are to a mariner. The plan is not a haphazard thing. It is the result of careful thought of what result must unavoidably follow this or that or the other course of action and involves the selection of that course of action which, on the basis of mature deliberation, can be shown to offer the best prospects. The plan should be specific—it should state definitely what will be done, when, and, in some instances, why.

Profit Leakage.—There are, after all, only a few points at which a job can go wrong. Take this concrete paving job as an illustration. Where are the points at which the profits can leak out? There are only six of them:

1. The materials may cost more than was anticipated.
2. The yield from the materials may be less than it should have been.
3. The number of men employed may exceed the number planned on.
4. The wage scale may rise.
5. The number of hours work actually obtained per day may be low.
6. The production per hour—that is, the number of batches turned out per hour—may not agree with the production plan.

Each of these six fields is totally separate and distinct. They do not overlap. The causes affecting losses in one of them have no necessary relation with losses in any other. They therefore offer a specific basis on which to rest the plans for prosecuting this job—the basis on which to determine the "how" of getting a profit. Each of

these fields must be examined and a calm, calculated determination made of what must be done here if the desired cost is to be had. Thus:

Materials for the last job cost	95 cents
Those for the new job will cost	92 cents
The yield last year was	2.15 sq. yds.
The yield this year should be	2.20 sq. yds.
Last year's crew contained	56 men
This year the crew must be cut to	52 men
The daily payroll, last year, was	$196.00
The daily payroll, this year, must be held at	180.00
Last year the time worked per day averaged	8.2 hours
This year the working day must average	9 hours
Production per hour last year was	80 feet
This year production per hour must be kept up to	90 feet

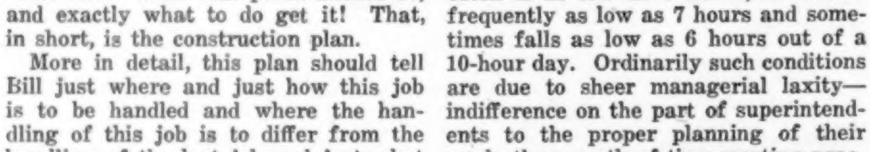
And if this can be done the job just taken will show a good profit!

Efficiency No Accident.—The thought it is desired to emphasize is that every highway job can be divided into specific, practically independent fields and that with past performance as a guide, the question must be frankly raised as to what improvement it is possible to obtain in each and how it is to be obtained. Let me say again that efficiency is no accident. "Do the best you can, Bill," is no basis for job control. The management is responsible for the plans. Bill, the superintendent, is responsible for their execution. But before Bill can be held for a profit on that job, somebody must have thought his way through that job clear to that profit, must know what that profit should be, and exactly what to do get it! That, in short, is the construction plan.

More in detail, this plan should tell Bill just where and just how this job is to be handled and where the handling of this job is to differ from the handling of the last job and just what results are expected. And the plans must not only be workable—they must be made to work. Bill must understand that explanations and excuses never pass as legal tender at the bank—that his sole responsibility is results.

To assist him in obtaining these results and to assist you in maintaining a close check on whether these results are being obtained, a job schedule should be prepared. Such a schedule will show just how much of the work should have been completed at the end of each week or of each half month or other specific period. Weather losses must, of course, be given due allowance but after they have been given due allowance it is entirely possible to predict the course of the job and to hold it to this course. Production can fall below schedule only if the hourly rate of production is low, or the number of hours worked per day is low, or whole days are lost by lax management and poor field control. If there is lax field management and the job lags, about the only solution is to get rid of Bill and find a better superintendent.

Too Much Time Lost.—It really is astonishing how much time can be wasted by a lax superintendent. Last year the records collected on a group of half a dozen projects, lying in the same rain belt—time losses chargeable to rain and wet subgrade being about 20 hours in each case—showed other miscellaneous time losses which amounted to from 27 hours to 120 hours —12 full days or almost half of a normal month. Production during this same month ranged from 155 hours to 225 hours. Average daily production—after taking out all weather losses—often is as low as 8 hours, is not infrequently as low as 7 hours and sometimes falls as low as 6 hours out of a 10-hour day. Ordinarily such conditions are due to sheer managerial laxity—indifference on the part of superintendents to the proper planning of their work, the growth of time wasting practices in going to and from the job, the tendency to knock off early after a good run, etc. Indeed, such conditions are so prevalent that if it were not known positively that the superintendent who got 225 hours of work out of his men on the job referred to above, got along with them better than the



Don't Place Your Stock on Soft Ground. This Man Tried It and Marked Up a Loss of 2,000 Tons of Aggregate, or 15 Per Cent of the Total Pile

Don't Place Your Reliance on Old 2-In. Pipe to Supply Water for a 5 or 6-Bag Paver. A Bursted Pipe Line Will Keep You from Pouring Concrete Just as Effectively as a Broken Mixer

man who got 155 hours of work during the same month, it might seem reasonable to assume that customs dictate some of the time wasting practices in vogue on so many construction jobs. But the facts appear to be otherwise, so the conclusion is that the correction of managerial laxity in the field administration of construction work—principally better planning of the field work and the eradication of time wasting practices—rests squarely on the management and presents today one of the outstanding fields in which to work for greater efficiency.

Using the Working Hours.—There is, of course, no escaping the fact that if the mixer turns out concrete or the shovel loads wagons during only 8 out of the 10 working hours, production necessarily suffers. Morover, the fact that there are jobs where 8 hours work are done during practically every period of 8 working hours or 10 hours work during each period of 10 working hours rather definitely precludes any argument that this cannot be done. The facts secured would, I am sure, surprise a good many contractors, if a reliable man was placed on each job to report confidentially the exact minute the first charge went into the mixer in the morning and at noon; the exact time the last batch went in at noon and in the afternoon and the length and cause of each delay exceeding 5 minutes. I am not a believer in "gum shoe" tactics in management, but the studies of the Bureau of Public Roads in this field reveal so much laxity in the matter of the actual

Don't Rely on Roadside Ponds for Your Water Supply. They Always Go Dry When the Best Weather for Pouring Concrete Arrives

utilization of the full working day—so much of a tendency to allow difficulties of one sort or another to become an excuse for shutting down the primary producer on a job before they in fact constitute a reason for so doing—that the conviction persists that responsible contractors do not have the facts in their possession or they would take drastic remedial action.

Proper Personnel and Equipment.—It has been noted that production can fall below schedule only if the rate per hour is not secured or if the number of hours worked is low. Both of these should be carefully studied by the contractor and the factors controlling the situation appraised before these rates are established. But while the matter of managerial laxity can be covered in this way, the matter of the hourly rate of production cannot. To attain any given rate of production the equipment must be made available and the proper personnel provided. On a paving job the contractor may reasonably demand, and actually can obtain, from 9 to 9½ hours of production out of every 10 working hours after allowing for weather losses and if he does not get it he can feel reasonably certain that lax superintendence is the basic difficulty. He may also, if he is working a 5-bag paver on standard Maricopa section pavement, ask for a production of 90 ft. an hour or even 95 ft. an hour. These rates are entirely practical where a minute mix is used and have been attained on properly equipped jobs, but the superintendent cannot possibly secure such a rate of production if some unit in the equipment sent to the job has a capacity which is below this.

The Load Factor.—This brings up the matter of load factor. Perhaps that term demands a word of explanation. It really is not a term much used in highway engineering. Electrical engineers all understand it because they have become accustomed to the idea that in power distribution the possibility of profitable operation is vitally affected by the amount of load carried and its distribution throughout the day. So they invented the term load factor. If a power plant is working at a load factor of 50 that means that it is producing and distributing 50 per cent of its rated output capacity. The load factor, then, is a measure on a percentage basis, of the use which is being made of the equipment. Now, in electrical power distribution a high load factor commonly spells good profit and a low load factor a loss because operating costs are determined by the nature of the equipment rather than by the amount this equipment is producing. A 100,000 kw. power plant needs no more attention when operating at a load factor 70 than when operating at a load factor of 20. There is some difference in fuel consumption but all other operating costs remain pretty nearly constant.

It is exactly the same in highway construction. When a contractor plans the conduct of his work on a given job one of his most important problems is the selection of the equipment to be used on that job. If the selection is good a high load factor can be maintained. If poor, the load factor unavoidably will be low. Poor management in the field may reduce the load factor but good management can not improve it above the limit of the controlling equipment. But a high load factor spells profit while a low factor usually means loss.

Failure to Study Load Factor.—May I amplify this matter of load factor a little by using a few illustrations of the results of failing to study the load factor? In the operation of an ordinary horse drawn elevating grader outfit, the cost of operating the grader, with the cost of running the dump and any other operations which must be performed when any work is under way, commonly costs about $80 a day. Of course, this is a very general figure but it will do as well as any for the purpose of illustration. To produce at a low cost it is, of course, essential that this element in the outfit be run as near full output capacity as possible. Let us assume that 1,200 cu. yd. a day is capacity production for the elevator. The lowest possible operating cost in loading wagons and distributing the dirt delivered to the dump is, then, under these conditions, 6⅔ ct. per cubic yard. Now the daily operating cost will remain practically constant no matter what its output is because the same number of men must be employed, the same horses worked and the same machines used, no matter what production is secured. If, then, the load factor falls to 50 per cent, the loading cost necessary rises to 13⅓ ct. per cubic yard, and if it drops to 10 per cent the cost of loading rises to 66⅔ ct. a cubic yard! This is as unavoidable as the law of gravitation and as quietly but unalterably effective.

A load factor as low as 10 is rare. That is admitted. It is not, however, unknown. The speaker visited a job in the Middle West a couple of years ago and found the contractor stripping a gravel pit along the right-of-way as required by the plans for this project and hauling the material about half a mile. He was getting about 25 ct. a cubic yard for this dirt, but complained that he was losing money, which obviously was the case, for a hasty calculation showed that putting on wagons enough to bring the load factor on his grader up to 100—he was using only 6 wagons—would cut the cost of handling that dirt 50 ct. a cubic yard! He

Don't Try to Substitute Hand Labor for Teams and Mechanical Equipment. It Is a Sure Way to Give a Sad and Sorry Look to the Profit Column, and Without Profits Even Contracting Soon Loses Its Charm

didn't have the wagons and at that season could not rent them in that region, so there wasn't much he could do to help his situation, but had he studied the load factor on that job, he would have realized his situation early enough to have avoided much of the difficulty he was in.

Bureau of Public Roads Studies.—Last year the Bureau of Public Roads conducted studies on a steam shovel job where for some time shovels capable of rather easily taking out 600 to 700 yd. of material a day were actually producing less than 100 cu. yd. a day. Of course, the cost of merely digging and loading this dirt—none of which could have been rated as more difficult than fair common—exceeded 50 ct. a cubic yard merely because the load factor on the shovels was low.

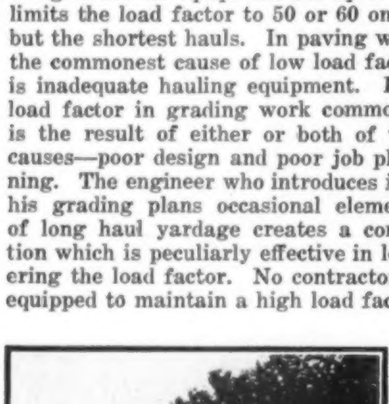
Low load factor is a common thing in the concrete paving field, also. Probably it is equally common in other branches of highway work but grading and concrete paving are specifically mentioned because they have been subjected to rather careful study by the Bureau. It is no uncommon thing to find that a concrete paving job is operating under an equipment set up which limits the load factor to 50 or 60 on all but the shortest hauls. In paving work the commonest cause of low load factor is inadequate hauling equipment. Low load factor in grading work commonly is the result of either or both of two causes—poor design and poor job planning. The engineer who introduces into his grading plans occasional elements of long haul yardage creates a condition which is peculiarly effective in lowering the load factor. No contractor is equipped to maintain a high load factor against both long haul and short haul. Inevitably he must either sacrifice load factor on his shovel or on his hauling equipment, or work out an arrangement which sacrifices something on both. The point it is desired to emphasize is that, particularly in grading work, the design itself may set a limit on the load factor that can be secured, and that design in this field is today of a relatively low order. Contractors would avoid many losses if they would study the load factor imposed by the design as affecting production with whatever outfit they will use if the work is secured, before bids are entered. In this way jobs so poorly designed that their cost must unavoidably be high can be avoided.

Don't Build Your Loading Platforms Too High, for It Costs Money to Lift Cement by Hand. Have the Loading Platforms Higher than the Trucks and Dump the Bags Direct from the Hand Trucks

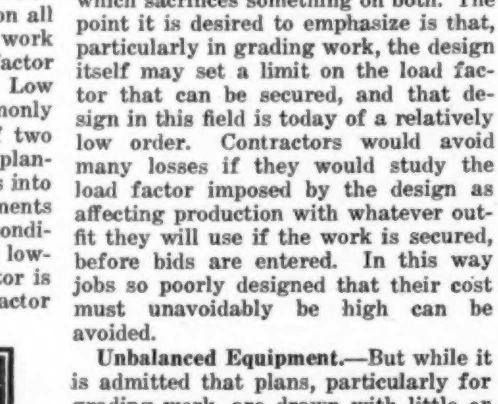
Unbalanced Equipment.—But while it is admitted that plans, particularly for grading work, are drawn with little or no consideration of the load factor, it is quite as true that contractors, speaking generally, make no adequate appraisal of this condition either before bidding or after the award, and so often fail to get all the profit there is to be had whether the job is well designed or is poorly designed. This most obvious cause is unbalanced, uncoordinated equipment. The contractor who sends a standard onto a long haul grading job invites financial trouble because, inevitably, his shovel will work under a low load factor. The mixer crew costs about $200 a day. To send out half of the trucks needed in order to deliver all the material that the mixer can mix, unavoidably doubles the cost of laying that pavement. Such facts are as unescapable as that two and two make four. But it rests with the contractor to correct them. Bill can only use the equipment sent to him. The home office—usually the contractor himself—is responsible for approving the outfit sent out—for making the plans on which that profit depends—and if the various parts of the plans, no one is more vital than the selection of equipment for a high load factor.

Of course, the personnel and the equipment are tied very close together. When the matter of methods is added, the size of the crew as a factor in cost is about as definitely determined as anything can well be in the construction business. The material encountered will affect the crew a little, but, speaking in general terms, the contractor can and should definitely prescribe the methods to be used and the men and the equipment to be employed and having done this should rather arbitrarily insist that the job must be run that way unless Bill can show that he has a better way. Profit, then, depends on knowing how to do the work and on how many men are needed and seeing to it that the work is done in that way with no more than that number of men.

Improved Management Means Profit.—I am not going to say much about the field operation of the job, not because there is nothing to say—for on the contrary, a good deal could be said—but because profit depends more on improved management than it does on improved field control. Still it may be well to suggest that there are points relative to field operations which deserve attention. Training the operators



Don't Neglect the Maintenance of Track



Poor Track Is the Most Frequent Cause of Wrecks and Wrecks Cost Money

on important equipment units is one of these. Does your mixer operator know how to turn out a batch every 75 seconds and has he the skill and the endurance to do this all day long if the material is delivered to him? It is vital to you that he have this skill and this endurance for topnotch production cannot be secured without it. If he has the physical capacity and the mental alertness but not the training, can your superintendent train him? He may be able to train himself, but that is asking a good deal of a mixer operator. He should be carefully coached in exactly what to do—and someone on the job should know how proper operation can be secured. The crane is another important equipment unit. Can the operator put two full buckets a minute into the hopper and do this all day long? Does the plow shaker really know how to set the disk to put on a quick load? Is your shovel operator able to load three wagons (2 dippers to the wagon) every 2 minutes in good common if you can get the wagons to him? His shovel is capable to doing even better than this if he knows how to use it. Does he know how to use it, and if not, does your superintendent know how to train him?

Pertinent Questions.—These are pertinent questions, for maintaining a high load factor depends on proper operation as well as on proper co-ordination. In short, putting enough wagons on that job won't do much toward improving production if the operator on the shovel is unable to get more than 60 or 70 per cent of capacity out of it, or if Bill doesn't know how to keep these wagons moving properly. The same thing can be said of men in other positions. To reduce the labor requirement to a minimum, the men must be trained to handle the work assigned to them properly. This reduces the burden on them as well as the number of laborers required.

The arrangement of equipment also could be advantageously discussed at some length. There also is the matter of the extra equipment needed in order, as far as possible, to avoid the effect of losses in time which cannot be foreseen. These occur on every job and are a constant problem. Time, however, is limited, so I will turn to the last subject it is desired to mention in this connection—the matter of keeping up the load. In grading work it costs as much to haul half a load as it does to haul a full load. In paving work it costs as much to haul, to mix and to place a short batch as to handle a full batch. This should need neither argument nor explanation, for in either event the same equipment and the same force are employed during the same period of time. On grading work short loading is apt to be due solely to the improper training of operators, but on paving work the materials rather than the operators commonly are at fault. Then, too, in paving work even a full batch may yield a low footage. This is due to inaccurate preparation of the subgrade. Underruns in footage may then be the result either of characteristics in the materials or of poor subgrading or of a combination of the two. But a 5 per cent underrun in footage on a concrete pavement costs you, as a contractor, just about as much as your total payroll—not far from $200 a day, if production is 2,000 yd. a day! This is a sum quite sufficient to justify the closest attention to the selection of materials for a high yield and to preparation of the subgrade with every precaution as to accuracy.

Efficiency Is No Accident.—These, gentlemen, are perhaps the most important points at which greater efficiency can be had in highway construction work. The presentation is not wholly adequate because no subject as broad as this one can be more than sketchily handled within the time allotted for a discussion of this sort. Many details must unavoidably be omitted and even the important ones have to be dealt with in general terms. There is, however, in all of this, one point I wish to stress again—that efficiency is no accident. It is only by a careful study of such matters as those touched on here, by the analysis of the specific conditions controlling on each job, by resolving the decisions made into definite plans and the enforcement of these plans that efficiency can be created and profits secured under the intense competitive conditions now prevailing in the highway construction field.

$75,000,000 Highway Contract Awarded to Warren Brothers Co.

The contract for constructing the Cuban central highway has been awarded by the Cuban Government to Warren Brothers Co., Boston, Mass. This highway extends from Guane at the western end of Cuba to Santiago de Cuba at the eastern end and is 750 miles in length. About 8,000,000 sq. yds. of pavement are to be constructed of which about 7,000,000 sq. yds. will be Warranite-bitulithic pavement. The balance will be granite block pavement, Through the towns and cities the highway is to be 25 ft. wide; the remainder will be 20 ft. in width. The contract amounts to $75,896,653. The Cuban government undertakes to pay for the work from funds collected in special gasoline and other taxes. Payments will be made from time to time as the work progresses. It is estimated that eight years will be required to pay for the entire job, but if through increases of taxes or by other financial arrangements the government is able to make earlier payment the work can be speeded up. The contractor, for instance, agrees to do the work in five years provided the funds are available to pay for it at that rate.

Joe Helm Now President of the Asphalt Association

Joseph S. Helm, who was elected president of The Asphalt Association at its annual meeting on Jan. 13 in Chicago, is one of the best known men in the highway industry. He is a native of Kentucky and was graduated from the University of that state. His first job was holding a rod for surveying crews of the Chesapeake & Ohio R. R. whose forces he joined in 1900. Later he was made resident engineer in charge of construction but after seven years he resigned to become associated with the Standard Oil Company of Kentucky, where he soon gravitated into selling road oils and binders. Getting around among highway commissioners, engineers and contractors proved congenial work with the result that Mr. Helm went into asphalt construction work. Later he became identified with the Standard Oil Company of New Jersey, with Atlanta, Ga., as headquarters. Eventually he located at New Orleans with the Standard Oil Company of Louisiana as manager of the asphalt sales department.

A short time ago Mr. Helm was appointed general manager of asphalt sales at home and abroad for the Standard Oil Company of New Jersey.

C. G. Sheffield, formerly in charge of the asphalt department, Standard Oil Company of New Jersey, was placed in charge of sales in the lubricating department. Under Mr. Helm all the asphalt sales work of the New Jersey company will be centered at 26 Broadway, New York City. With his transfer to the lubricating oil department as manager of sales, Mr. Sheffield retired January 13th as president of The Asphalt Association, a position in which he has served the asphalt industry most effectually for the past two years. In preparation for the wider field in his position with the New Jersey Company, Mr. Helm spent several months during 1926 organizing asphalt sales centers in Europe. Bruce Aldrich, formerly manager of The Asphalt Association's branch offices in Toronto and New Orleans, was one of those who accepted a place in the European sales organization established by Mr. Helm.

Joe S. Helm is one of the keenest and most successful men in the road building field. Few men have a wider acquaintance among producers, public officials, engineers, contractors and machinery manufacturers. He possesses a naive charm, quick wit, aggressive personality and resourceful nature that have made him an exceedingly popular and effective salesman and executive. His host of friends throughout the country will wish him well in his new capacity of general manager of the Asphalt Sales Department, Standard Oil Company of New Jersey.

The Traffic Problems of a Small City

Conditions at Lafayette, Ind., and Measures for Remedying Them Described in Paper Presented Jan. 21 at 13th Annual Road School, Purdue University

By A. R. ROSS
Mayor, Lafayette, Ind.

The automobile traffic problem is one that is confronting practically every city and county seat of any material size. This problem has rapidly developed in recent years and with an average annual increase of from 10 to 12 per cent in the number of automobiles, the problem will become more acute for each municipality. Most of our Indiana cities have comparatively narrow streets, with but little, if any, opportunity to widen them. The object in traffic control is the conservation of life and limbs and the orderly movement of the traffic. In the points to be submitted in his paper the conditions in Lafayette will be dealt with, in the belief that with slight modification the conditions are present in every Indiana city of any size.

Street Conditions at Lafayette.—The width of the down town streets in Lafayette from curb to curb varies from 30 ft. to 51 ft. The maximum width is found on the four sides of the public square, but the greater majority of the streets will not average over 36 ft. to 38 ft. in width. Automobiles parked parallel to the curb will extend 6 ft. into the street and where angle parking is established the machine will extend from 10 ft. to 13 ft. into the street. Our principal street has an average width from curb to curb of about 39 ft., and with double street car traffic traversing its center, and a solid row of automobiles parked parallel to the curb on both sides of the street, it can be readily seen that there would not be sufficient room between the street car and the parked automobile for the passage of any traffic.

This condition results in numerous traffic blockades due to the stopping of street cars to take on and let off passengers. This condition also constitutes a constant menace of obstructing the fire department in making its runs where it would be most necessary for it to arrive promptly, in the congested portion of the city.

Parking and Traffic Census.—In order to secure more definite data, upon which to base corrective measures, and with the co-operation of the Engineering Department of Purdue University, under the active direction of Prof. G. E. Lommel, a 12-hour traffic and parking census was taken on Saturday, March 6, 1926. This was a rainy day and would not show a maximum number of cars that would be on the congested streets, but some very interesting conditions were disclosed.

The point of heaviest traffic conditions was shown to be at the corner of Ninth and Main Sts., which is a transfer point for street cars leaving in four directions. Without counting the north and south bound motor traffic, or the west bound traffic turning into Ninth, it was shown during the 12 hours, 4,594 vehicles and street cars passed through this busy center. The result of this showing was to place a traffic officer at that intersection.

Of the total traffic, 32,747, moving in and out of the business district—5,602 or 17.1 per cent was truck traffic; 566 or 1.7 per cent was horse drawn, and the remainder, about 81 per cent was motor driven, both business and pleasure.

Another condition prevailing in Lafayette consists of the two bridges crossing the Wabash River and these furnish the only means of crossing the river within a radius of 7 or 8 miles in either direction. The Main street bridge was shown to be the busiest place disclosed in the census as 7,922 vehicles passed during the 12-hour count, reaching a maximum of 742 for the half hour period from 4:00 to 4:30 p. m. As disclosing the relative importance of the two bridges across the river it was shown that the total traffic over both bridges was 8,359 vehicles, and of this number 94.8 per cent passed over the Main street bridge while the Brown street bridge carried but 5.2 per cent. This showing clearly indicates the desirability of so routing traffic as to relieve the Main street bridge and throw some of the traffic to the Brown street bridge to the north.

Through Streets Designated.—In order to help toward the solution of this problem and to relieve the down town portion of Main street of its heavy traffic congestion, an ordinance was enacted creating four through streets running east and west parallel to Main, two to the north and two to the south of that street. The result of the operation of this ordinance has been very gratifying in relieving Main street of considerable traffic.

By Passing Tourists.—In order to prevent additional congestion of our Main street, resulting from the construction of State Highways, the city administration in co-operation with the State Highway Commission are routing as much of the through traffic down the side streets and across the but litle used Brown street bridge as possible. In this connection it might be said that it is to the very material advantage of cities to co-operate with the State Highway Commission in by-passing tourists from their congested business centers, and not be mislead by any sentiment of local merchants in their mistaken desire to have traffic routed through the center of the town. Most tourists wish to go through the city and appreciate the opportunity of doing so without being delayed by passing through the congested district and those tourists who wish to stop will do so regardless of how the through traffic is routed.

Railroad Traffic Obstacles.—Another very definite traffic obstacle with which we have to contend in Lafayette is the passing of long freight trains over the Monon and Wabash Railroads through the business section of the city. This obstacle is most marked in connection with the Monon Railroad as it passes directly through the center of the city from north to south on Fifth street and during the 12 hours census approximately 8,000 automobiles crossed this railroad. During this period moving or stationary trains occupied the crossing for a total of about 29 minutes, which would mean that roughly 350 automobiles were held up for approximately 30 minutes. This certainly indicates a definite economic loss of considerable importance.

Parking in Business Section.—Closely allied with the traffic problem in the way of traffic obstacles are the automobiles that are permitted to be parked on our down town streets. A very material addition to this type of obstacle results from the local business or professional men who park their cars all day and thus maintain a constant traffic obstacle and prevent the out of town customers of the business men the convenience of ready access for shopping purposes.

In the parking census that was taken, as a part of the study, a total of 10,457 parked cars were counted. Because of a rather heavy rain in the afternoon this census was not as completely successful as was hoped for it. However, the result disclosed the selfish use of the streets for parking purposes by a number of citizens, namely

60 cars were parked for 9 hours or more
83 cars were parked for 8 hours or more
98 cars were parked for 7 hours or more
120 cars were parked for 6 hours or more
143 cars were parked for 5 hours or more
180 cars were parked for 4 hours or more
282 cars were parked for 3 hours or more
382 cars were parked for 2 hours or more
558 cars were parked for 1 hour

In round numbers 1,700 cars could be parked in the territory covered by the parking census and at 2:00 p. m. on March 6th almost 1,400 cars were parked in this district, of which 62

were double parked in 14 different blocks. It is estimated that these parked cars cut down the street efficiency for traffic between 25 and 35 per cent. During the day 88 cases of double parking were reported on 28 different blocks.

Conclusions From Census.—Some of the conclusions submitted as the result of this traffic and parking census were that either a no parking or limited time parking regulation be established on Main street.

That some provision should be made to care for the obstruction caused by trucks backed up to the walk for loading and unloading.

That the number of taxi cabs that could be parked in front of the taxi offices should be strictly limited.

That parking space, for long time parking, should be provided either by the city or the merchants.

That as much as possible of the traffic be diverted from the congested Main street bridge to the less used Brown street bridge in crossing the river.

Bonding for Municipal Free Parking Ground.—In attempting a solution of the acute traffic and parking situation confronting Lafayette, an ordinance was first enacted, as already noted, establishing four through streets parallel to Main street and encouraging traffic to use these streets. The next measure taken up for consideration was that of a limited time parking ordinance to cover the more congested business districts with one and two hour parking limits, according to the importance of the street. Early in the consideration of this problem we were confronted with the advisability of providing a free parking space for long time parking in order that the enactment and enforcement of a limited time parking ordinance would not result in residents of the country districts going to the small villages and staying away from the county seat because of no available place for parking their cars while in the city. Since it would be very difficult, if not impossible, to prevent residents of the city from using most, if not all, of the parking spaces available on streets outside the limited time parking district; there would be little, if any, long time parking space available for the people from the country, unless they would go to a considerable distance from the business section of the city. As a solution of this problem an option was secured on property located between the two bridges crossing the river, and easily accessible from both, to be used as a municipal parking ground. The plan involved in connection with the parking ground—a small building equipped with toilet facilities for both men and women, a free checking room for the patrons to check their parcels, the whole parking space to be encircled by a fence and in charge of a custodian to render needed service to visitors to the city and guard against theft of automobiles. The city council authorized a bond issue of $52,000 to cover the purchase and equipment of this parking ground.

Opposition to Bond Issue.—We immediately encountered opposition, almost wholly of a political character, which resulted in an appeal being taken to the state board of tax commissioners by a group of local remonstrators. A public hearing was held by one of the state tax commissioners and not one shred of evidence was submitted by the remonstrators to sustain the points included in their remonstrance and the large audience of local business men who were in attendance signified they were very much in favor of the proposed bond issue. The attorney for the remonstrators raised the legal question that a city council did not have the power to authorize a bond issue for such a purpose, but the state tax commissioner stated that that was a question for the courts to decide, and on the merits of the proposed bond issue for meeting a very great public need the state board of tax commissioners subsequently approved the bond issue.

The law under which the city administration proceeded in its effort to secure this much needed assistance in solving the parking problem was "An Act Concerning Municipal Corporations —Approved, March 6th, 1905 under Section 92" in which the following power is granted to the board of public works: "To condemn, rent or purchase any real estate or personal property needed by any such city for any public use." It would be difficult to conceive of anything that could be more clearly established as constituting a public use than this plan of providing a parking ground for a large number of automobiles in order to make it convenient for out of town shoppers and long time visitors to park their cars, and to facilitate the enforcement of a limited time parking ordinance, to better meet the needs of the customers of our local business men, and to clear our local streets from the constant menace encountered by our Fire Department in making its runs to fires.

When the bond issue was advertised for sale, the different bond houses submitted their bids subject to the approval of their attorneys. The attorneys of the bond company who were the successful bidders, advised the bond house against purchasing the bonds, because of the fact that Lafayette was the first city in Indiana to issue bonds for the purpose of a Municipal Parking Ground and that there was no court decision establishing the fact that this constituted a public use within the meaning of the law. These attorneys were influenced in their decision by information conveyed to them by local opposition to the project, that a Lafayette attorney had been retained to take the matter into the courts and thus involve the bond issue in litigation. These attorneys did not question the very great need of Lafayette for such a parking place to relieve the congested business streets and they did not question that such a project constituted a public use within the meaning of the law. But in the absence of a court decision definitely establishing that fact, they would not recommend the purchase to the bond company because the small commission it would receive would not justify it in placing a bond issue in the hands of any customer that was to be involved in litigation. This matter is still pending but it is of such a character that it should be of interest to the officials of every city in Indiana.

A number of cities in the state are almost certain to be confronted with the necessity of doing something to relieve their congested business streets and retain the out of town customers of their local merchants, as that kind of business constitutes an important factor. For any city to purchase ground to provide a free municipal parking space for a large number of automobiles for long time parking, and to facilitate the enforcement of limited time parking regulations would seem to be a very clear and very definite public use. By no argument could it be proven that such a project was not for the purpose of giving a definite public service. But in the absence of a court decision establishing the fact that such a project constituted a public use, any city in the state would probably encounter the same difficulty that Lafayette did in negotiating with financial institutions for the purchase of bonds authorized for such a purpose.

Factors in Enactment of Parking Regulations.—In the enactment of no parking and limited time parking regulations in our cities, there are a number of factors to be taken into consideration which will apply to most of our cities with but slight modifications to meet local conditions. No parking zones must be established where needed to meet the needs of traffic. The operation of street cars, taxicabs and large motor busses with the location of their terminals are factors to be taken up and definitely provided for in any regulatory measure. The establishment of through streets and the by-passing of through tourist traffic are also items to be considered in the solution of the general problems of relieving the narrow congested streets in the business portion of the city from its heavy burden of traffic.

In conclusion it is hoped that some of the points submitted in this paper may be of service in the way of suggestions to the officials of other cities in attendance at this meeting. The paper has dealt rather specifically with conditions existing in Lafayette and the definite measures undertaken to solve our local problems. We are fortunately situated adjacent to Purdue University and were enabled through the co-operation of its representatives to conduct a valuable traffic and parking

census which gave us definite information on which to base remedial measures. In other cities not so fortunate as to have the expert service available from Purdue University, it should not be very difficult to have a traffic and parking census taken through the co-operation of the Boy Scouts or some similar organization. The Boy Scouts of Lafayette actively assisted in the traffic and parking census we held. If each city will learn by such a census its own traffic and parking needs the officials can then plan along definite lines to meet the local problems presented. These problems for all of our cities will become more acute as the number of cars increase and any plans adopted for their solution in any city should provide for the future demands of traffic insofar as it is possible to do so.

New Bear Cat Shovel

A new ½-yd. rope crowd shovel has been brought out by The Byers Machine Co., Ravenna, O. The new shovel, which is designated as "Byers Bear Cat Model 27-R," was first shown publicly at the recent Chicago Road Show. In the new product the length of boom, dipper stick and size of bucket follows standard practice for machines of this type. The boom is of steel and is of the box girder type construction and is well designed, being heavy enough to get good crowding power and still not heavy enough to cause unstability of the machine. The dipper stick is of the double type, working in double saddle block outside of the boom, and is made of seasoned oak timber completely armored with steel plates. The boom foot and the hinge casting at the end of the dipper stick are of steel, extremely large and heavy.

The rope crowd is accomplished by means of a drum actuated by a clutch at each end, each of which operates the drum in the opposite direction. The two clutches are operated by one lever and the operation is standard with three levers and one foot brake. An extra brake is provided to assist in holding the dipper stick in any position as well as for the back drum when some other attachment is used.

The crowding line starts at one end on the dipper stick, then around a sheave on the shipper shaft and thence to the back drum by way of a sheave on the boom foot pin and the step sheave; this cable is then wrapped around the drum at one side and then anchored in the middle of the drum, then wrapped around the other end of the drum and continued over a special top sheave, and down around another sheave on the boom foot pin, then around another sheave on the shipper shaft and is anchored to the other end of the dipper stick by a turn buckle which gives a means of taking up stretch in this cable.

This crowd is stated to be extremely sensitive, easily operated, very fast, and absolutely positive in action, not depending on any other factor in the operation of the machine, it being an independent operation capable of being operated by itself alone.

The bucket is of good design and of a shape that will fill. It has a capacity of 85 per cent of a ½-yd. struck measure so that it will easily hold a ½ yd. when heaped.

The standard Bear Cat attachments consisting of skimmer, ditcher, clamshell and backfiller all fit the 27-R shovel without change and without the removal of any part of the mechanism.

Byers Bear Cat Model 27-R Excavator

New 6-Cylinder Trucks

The Ruggles Motor Truck Co., Saginaw, Mich., has recently announced two new six-cylinder chassis, Model 18, 1¼-ton capacity, and Model 25, 2-ton capacity. These new models have been designed to fill the demand for higher speed, greater flexibility and lower loading height for commercial hauling, and are produced in addition to their well-established line of four-cylinder models.

The Model 18, 1¼-ton capacity, is stated to incorporate many new features. An unusually low frame height is made possible by using underslung rear springs together with a unique cutout frame construction over the rear axle, which entirely eliminates any frame kick-up but retains all its advantages of low frame height.

The chassis is so designed that an interchangeable four or six-cylinder power plant can be used, in accordance with the requirements of the buyer. The four-cylinder engine is a Lycoming "CT" with five bearing crankshaft,

Model 25 with Coupe Cab and 5x11-Ft. Stake Body

forced feed lubrication, 3⅝-in. bore by 5-in. stroke. The six-cylinder engine is Lycoming "S" with four bearing crankshaft, forced feed lubrication, centrifugal water pump cooling, 3¼-in. bore by 5-in. stroke. The radiator shell is of polished cast aluminium with Perfex core.

The chassis weight is 3,000 lb., with an 800 lb. body allowance and chassis is furnished in two wheelbase lengths, standard 134 in., long 154 in. Four standard Ruggles built bodies are furnished for the Model 18, including platform body with two section stake rack and sign board, express body with flare sides and stake pockets, express body with three post full canopy and curtains and de luxe inclosed panel of plymetal construction with dome lights.

The Model 25, 2-ton chassis, is powered with a Lycoming six-cylinder engine, four bearing crankshaft, forced feed lubrication, centrifugal water pump cooling, 3⅝-in. bore by 5-in. stroke. A pressed steel radiator shell mounted on springs with a Perfex core is used.

The chassis weight is 4,200 lb. The chassis is built in three wheelbase lengths, standard 160 in., long 177 in., extra long 189 in.

Chicago Road Show and Convention

Attendance, 25,000; Number of Exhibitors, 305; Value of Exhibits More Than $3,000,000

The 24th annual convention and 18th annual road show of the American Road Builders' Association, Jan. 10 to 14, at Chicago, were without question, the largest and most successful meetings of their kind ever held in this or any other country. The attendance was in the neighborhood of 25,000. The number of exhibitors was 305, an increase of 27 over the previous year, and the value of their exhibits was more than $3,000,000.

The various sessions of the convention were held at the Palmer House, and the exhibits of road construction and maintenance equipment and materials were housed, as in previous years, in the Coliseum and adjoining buildings.

Among the important actions taken at the convention was the tentative launching of a national highway safety campaign as proposed by the fiscal committee of the association. The campaign will be conducted out of the new offices of the American Road Builders at Washington. Editorial comment on this will be found on page six of this issue. A new feature of the convention was the special highway exhibits by the U. S. Department of Commerce, U. S. Bureau of Public Roads, Canadian, Alaskan, Dominician Republic, Mexico, Highway Research Board, American Association of State Highway Officials and 11 states. These were located at the Palmer House.

An international aspect was given to the convention by the presence of more than a score of official delegates from Pan-American countries. These included delegates from Mexico, Cuba, Uruguay Dominican Republic, San Salvador, Argentina and Colombia. The convention was divided into nine sessions—three general sessions for both engineers and contractors, three sessions for the discussion of engineers problems and three sessions for the discussion of contractors problems.

The general subjects at the engineers sessions were : (1) "Work Preliminary to Construction," (2) "Construction" and (3) Operation and Maintenance. Eleven papers devoted to these subjects were presented.

The general subjects at the contractors session were: (1) "Contracting as a Business;" (2) "Practical Operating Methods;" (3) "Enlargement of Contractors' Field Benefitting Political Sub-divisions." These subjects were covered by 10 papers.

Several of these papers, as well as some of those presented at the general session will be found elsewhere in this issue.

One of the general sessions was devoted to addresses by Pan-American delegates on the highway situation in their countries. Senor F. Diaz Leal, outlined Mexico's highway situation and promised that within the next few years the development of roads in Mexico should make a strong fraternity of Mexico and the United States.

Senor Andres Ortiz spoke on the new systems of highways contemplated in Mexico. He described the exotic beauty of antique Mexico, its traditions, volcanoes and primitive highways. "With the building of modern highways," Senor Ortiz concluded, "we hope to achieve a better and greater understanding with the great American people."

"Road Construction in Cuba" was discussed by Alberto Coralle, Constructing Engineer, Department of Public Works. Chile, Argentine and Uruguay also were represented.

The routine features of the convention were broken by several functions and parties. The most important of these, of course, was the annual banquet which was attended by more than 2,000. Wilbur D. Nesbit officiated as toastmaster, introducing President H. G. Shirley, Gutzon Borglum, famous sculptor who urged the construction of trans-continental highways, and Capt. Irving O'Hay, famous New York humorist, who gave spice to the program. There also was a gala supper dance at the Club Chez Pierre, and a supper dance in the Red Lacquer Room of the Palmer House.

At the business meeting several new officials were elected to take office next May.

Charles M. Babcock, Chairman of the Minnesota State Highway Commission, was elected president of the American Road Builders' Association to take office in May. He will succeed Henry G. Shirley, Chairman of the Virginia State Commission as chief executive of the Association.

Mr. Babcock has been active in affairs of the American Road Builders' Association for many years, and was a member of the Board of Directors at the time of his election.

A group of new directors were elected to fill expiring terms. Three vice-presidents were re-elected and another selected from the board of directors.

The vice-presidents are: Sam Hill, Honorary Life President of Washington Good Roads Association; S. F. Beatty, President, Austin-Western Road Machinery Company, Deputy Engineering Executive, Pennsylvania Department of Highways; S. T. Henry, Director, Pan-American Confederation for Highway Education.

Sen. James H. MacDonald, New Haven, Connecticut, was re-elected treasurer of the Association. The directors elected were J. R. Draney, Asphalt and Oil, New York City; Richard Hopkins, Contractor, Troy, New York; Edward E. Duff, National Paving Brick Manufacturers' Ass'n., Cleveland; A. E. Horst, Secretary and Treasurer of Henry W. Horst Company, Rock Island, Illinois; T. A. Little, Vice-president Harrison Engineering and Construction Co., Kansas City; Fred R. White, Chief Engineer, Iowa State Highway Commission.

Non-Skidding Surface

Use of stone screenings as a finish for asphalt concrete surfacing was a feature of the Modesto-Stanislaus River reconstruction project in Stanislaus County, California, 7.8 miles of which was recently completed by the Valley Paving & Construction Co. of Visalia. According to December California Highways, this is one of the first projects of any magnitude on which the new method of finishing, designed to prevent skidding, has been tried out.

The original pavement was widened to 20 ft. by cement concrete shoulders, 2.5 ft. wide and 7 to 8 in. thick, placed on either side of the existing 15 ft. base, which was surfaced with asphaltic concrete, averaging 2½ to 4 in. in thickness. Two-foot rock borders 4 in. in thickness, when compressed, also were placed along the concrete shoulders throughout the project.

Specifications for the finish read as follows:

"Screenings for the surface finish shall be thoroughly coated with asphalt cement in the mixer and shall be applied to the surface immediately after the first rolling."

The screenings used were such as would pass through a ¼-in. square screen with not less than 90 per cent of the total being retained on a standard No. 10 screen. The amount applied averaged from 10 to 15 lbs. per sq. yd.

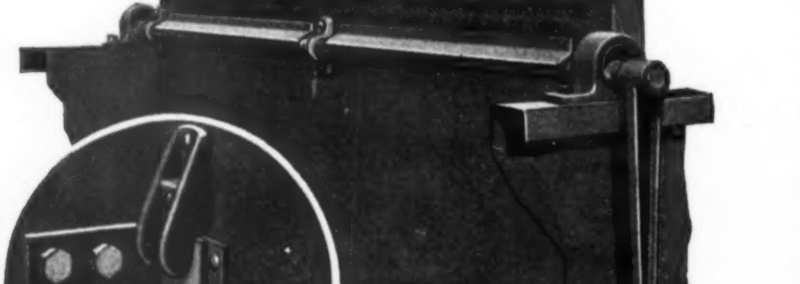
Toll Tax and Gas Tax.—Statistics gathered by the Kentucky Highway Commission show that if the auto user of today were required to pay the same amount of toll, per mile, that the preceding generation paid for the use of the Kentucky highways, the gas tax in the state of Kentucky would have to be 35 cts. per gallon instead of the present 3 cts. per gallon. In other words, it would require a gas tax of 35 cts. per gallon in order to approach the toll tax, per mile, paid by the early day Kentuckians for the use of the toll roads.

Motor Truck Production in 1926.—Over 530,000 motor trucks were made in 1926, according to statistics of the National Automobile Chamber of Commerce. Included in this total are approximately 15,000 motor buses. The truck production in 1925 was 497,452 units; in 1924, 374,317 units; in 1923, 392,760 units.

Swinging Batch Boards

There has been a tendency of late for contractors and truck owners operating on cement and concrete mix jobs to use dump bodies on their motor trucks equipped with swinging partitions. With the dump body correctly divided for batch loads, it is stated to be far more efficient in unloading at the skip of the mixer, to release the load batch by batch.

The idea of an eccentric control for the operation of the batch board or swinging partition has been developed and patented by the Heil Co., Milwaukee, Wis. The illustration shows the principle of its operation. When the operating handle for the batch board is raised the partition is lifted up about 1 in. by the action of the eccentric and released from its latch so that the load swings the partition open as it dumps out.



Close-Up View of Partition Latch

To lock the batch board in position again with the body lowered, the operating handle is pulled down, thus bringing the partition back so that it automatically hooks itself to the latch on he inside of the body side.

A Heil batch board or swinging partition consists of a divider plate of steel flanged over at all edges to give stiffness. The flanges are turned away from the load. With the new partition drilled in the body floor. Heil batch boards are made for any make or model dump body.

Industrial Notes

The Orton Crane & Shovel Co., Chicago, Ill., manufacturers of locomotive, crawler type and truck cranes, power shovels and grab buckets, has appointed G. S. Green Co., Inc., 72-74 Warren St., New York City, as eastern sales representatives.

Paul Bernard, General Manager in Europe for Wood Hydraulic Hoist & Body Co., attended the Road Show in Chicago in January. From Chicago, he went to the Wood factory in Detroit, where he exhibited pictures of numerous installations abroad. With Mr. Bernard was Fernand Géneve, manufacturer in France of Wood Hydraulic hoists and bodies. Mr. Bernard remained for the Wood Sales Convention at the factory on Feb. 10, 11 and 12, at which time the Wood Company will also have with them, R. Woodhead, Managing Director of Wood Hydraulic Hoist and Body Co., Ltd., Southport, England.

The Wehr Co., Milwaukee, Wis., manufacturer of an extensive line of Fordson equipment, has opened a factory branch office in Chicago at 2343 South LaSalle St. The branch will serve the Chicago territory of the Ford Motor Co. In addition to the necessary offices, a show room will be maintained together with a warehouse stock and adequate parts stock. E. H. Anderson is branch manager.

The Foote Co., Inc., of Nunda, New York, has appointed Frank Hall, of 152 West 42nd St., New York City, general distributor for Connecticut, that part of New York below a line drawn from the upper border of Connecticut to the upper border of Pennsylvania and the upper half of New Jersey. Mr. Hall has been connected with The Foote Co. for many years and is thoroughly familiar with the machine and its operation. He has been largely instrumental in placing the many Foote 27E Pavers now in this territory.

The Speeder Machinery Corporation last month moved its factory and general offices from Fairfield, Ia., to Cedar Rapids, Ia. Speeder Cranes and shovels are now being built in the new plant, which is a modern-equipped shop, with a present capacity of one complete Speeder a day. This capacity may be easily increased, as the plant is located on a plat of eight acres. The new factory is of brick and steel construction of the saw-tooth type, with a 40-ft. craneway over the assembly floor. The entire shop is served by an overhead industrial carrier system. The shop and offices are heated by automatic oil-burning superheaters, made by the P. M. Lattner Co., also of Cedar Rapids. The heated air is circulated by a fan system.

The Le Roi Co., Milwaukee, Wis., has taken over the business formerly conducted by the Beaver Manufacturing Co., also of Milwaukee, Wis., makers of Beaver heavy duty gasoline engines. With Beaver's line of gasoline engines, Le Roi Co. will now manufacture gasoline engines ranging in horse power from the small 3 to the big 160. The heavy duty Beaver Engines have been widely known for their "Brute" strength and have been serving the field for 25 years. The Beaver engines are solely intended for extremely heavy duty and will have a horse power range of 40 to 160. They are made in 4 and 6-cylinder sizes with a bore and stroke range of from $4\frac{1}{4}$x6 to $6\frac{1}{2}$x7.

One of the outstanding reorganizations of the New Year is that of the Williamsport Wire Rope Co., of Williamsport, Pa. With the purchase of the Cochran interests by a syndicate headed by Robert Gilmore, Edgar Munson, Logan Cunningham and C. M. Ballard, the control of this important industry virtually passes into the hands of old employees. The new organization while introducing new capital will not affect the personnel of the old organization who have within the past few years stepped into the limelight as an important factor in the manufacture and distribution of Telfax marked wire rope. Robert Gilmore, president, continues as the directing head—having been actively associated with the company for 34 years. Edgar Munson becomes vice president and treasurer. Logan Cunningham becomes vice-president and secretary and C. M. Ballard, vice president and general sales manager. These men have all been important factors in the upbuilding of the Williamsport industry to its present enviable position. No time is being lost by the new organization to put into effect one of the most progressive programs of their career, for the task of enlarging their present plant and the extension of present facilities has already begun.

New Trade Publications

Loading Bins and Aggregate Hoppers.—The Butler Bin Co., Waukesha, Wis., has just issued a new 68 page catalog devoted to its steel loading bins and aggregate measuring hoppers. The catalog is very complete in detail, profusely illustrated, and shows typical yard layouts and methods of handling coarse and fine aggregate.

Road Making and Maintenance Equipment.—A new 52-page general catalog of the Austin-Western line of road making, rock crushing, earth handling and street cleaning equipment has been issued by the Austin-Western Road Machinery Co., 400 North Michigan Blvd., Chicago. The style of this catalog is quite different from anything gotten out by the company in the past. Besides containing a large number of operating pictures the essential features of the equipment are conveyed simply and intelligently without burdening the reader with a great lot of details. Special catalogs on all of the Austin and Western machines contain more detailed descriptions and complete specifications.

Tractors.—A new catalog devoted to its models 20 and 30 tractors has been issued by The Cleveland Tractor Co., Cleveland, O. Complete specifications and ratings of the tractors are given as well as descriptions and illustrations of their various features. Numerous illustrations of construction operations on which the tractors are in use are included.

Machine for Concrete Road Joint Construction.—A catalog illustrating and describing the Flex-Plane system of constructing longitudinal and transverse joints for concrete roads has been issued by the Flexible Road Joint Machine Co., Warren, O.

Trailers.—The Miami Trailer-Scraper Co., Troy, O., has issued a circular illustrating and describing its line of trailers. Included is a description and illustration of the company's new 4-wheeled bottom dump trailer.

Road Machinery.—The Good Roads Machinery Co., Kennett Square, Pa., has issued a circular illustrating and describing its equipment.

Drill Sharpeners.—Bulletin No. 72-I, second edition, issued recently by The Sullivan Machinery Co., 122 South Michigan Ave., Chicago, describes in complete detail the Sullivan Class "C" light drill steel sharpening machine operated by compressed air. The Class "C" Sharpener is intended for making uniform and accurate bits and shanks for hammer drill service on ⅞-in. or 1-in. steel of any desired cross section. It also is equipped to forge pick point bits and collar shanks on 1⅛-in. concrete breaker steel or to put shanks on steel spades used in the Sullivan spader.

Excavator.—The Insley Manufacturing Co., Indianapolis, Ind., has just brought out a new 64-page catalog devoted to the Insley excavator. The excavator is illustrated and described and numerous illustrations of its use on various construction operations are given. A considerable portion of the catalog is devoted to illustrating and describing the mechanical details of the excavator and its various attachments. Specifications and shovel dimensions are given.

Crushing Equipment.—The Gruendler Patent Crusher and Pulverizer Co., St. Louis, Mo., illustrating and describing its rock and gravel crushing equipment. Specifications for the various equipment are included.

Road Building Equipment.—The C. D. Edwards Manufacturing Co., Albert Lea, Minn., has brought out a catalog illustrating and describing its line of Road graders (7 sizes), Fordson maintainers rotary snow plows, Fresno scrapers, slip scrapers, road drags, wheel scrapers, road plows, road rooters, culverts, intake grates for tile bar iron shears and bog land levelers.